WATER QUALITY MONITORING

AT PROMPTON RESERVOIR

DURING 2002

Prepared for

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Philadelphia District
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Contract No. DACW61-00-D-0009
Delivery Order No. 0033

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January 2003

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1.0 INTRODUCTION

1.1 PURPOSE OF THE MONITORING PROGRAM

The U.S. Army Corps of Engineers (USACE) manages Prompton Reservoir located in northeastern Pennsylvania within the Delaware River Basin. Prompton Reservoir provides flood control and a dependable water supply to downstream communities on the Lackawaxen River. Additionally, the reservoir provides important habitat for fish, water-fowl, and other wildlife, and recreational opportunities through fishing and boating. Because of the broad range of uses and demands that Prompton Reservoir serves, the USACE monitors water quality to compare with state water quality standards and to diagnose other problems that commonly effect reservoir health such as nutrient enrichment and toxic loadings. This report summarizes the results of water quality monitoring at Prompton Reservoir for May to October 2002. This report also discusses the relevance of the water quality measures to the ecology of the reservoir and makes recommendations toward future water quality monitoring.

1.2 DESCRIPTION OF PROMPTON RESERVOIR

Prompton Reservoir was designed to provide flood control, water supply, and enhanced water quality to downstream communities along the Lackawaxen River. The reservoir is located about 3 miles northwest of Honesdale, Pennsylvania, and dams a drainage area of 59.7 square miles. The primary surface water input to Prompton Reservoir originates from the West Branch of the Lackawaxen River. The reservoir is approximately 3 miles long and is about 30 feet deep at the face of the dam near the township of Prompton, Pennsylvania. Average annual discharges into the Lackawaxen River from below the dam are approximately 104 million gallons per day (USGS 1993).

1.3 ELEMENTS OF THE STUDY

The USACE, Philadelphia District, has been monitoring water quality of Prompton Reservoir since 1975. Over this time, the yearly monitoring designs have evolved to address new concerns such as health of public drinking water and contamination of sediments. The 2002 monitoring program follows that in most recent years and includes the following major elements:

- Monthly water quality monitoring of reservoir and upstream sources - to evaluate compliance with Pennsylvania state water quality standards and potential public health concerns;

- Sediment priority pollutant monitoring of PCB's, pesticides, and volatile organic compounds to evaluate sediment toxicity relative to USACE identified screening concentrations; and

- Drinking water monitoring - to ensure public health and safety by comparing water from a drinking water source to standards determined by the Safe Drinking Water Act (SDWA).

2.0 METHODS

2.1 PHYSICAL STRATIFICATION MONITORING

Physical stratification monitoring of the water column at Prompton Reservoir was conducted five times between May and October 2002 (Table 2-1). The final monitoring that was initially scheduled for late September was conducted in the first week of October. Physical stratification parameters included temperature, dissolved oxygen (DO), pH, and conductivity. Monitoring was conducted at four fixed stations located throughout the Prompton Reservoir watershed (Fig. 2-1). Surface water quality was monitored upstream at station PR-1 and downstream at station PR-4 (Fig. 2-1). Stations within the reservoir, PR-2 and PR-3, were monitored at 5-foot intervals from the surface to the bottom. All water quality parameters were measured with a calibrated Hydrolab water quality meter.

The results of stratification monitoring were compared to water quality standards authorized by the Pennsylvania Department of Environmental Protection (PADEP: Chapter 93. Water Quality Standards. 2000). The water quality standard for DO is a minimum concentration of 5 mg/L and that for pH is an acceptable range from 6 to 9. A summary of all of the water quality measures collected during monthly monitoring appears in Appendix Tables A-1 and B-1.

2.2 WATER COLUMN CHEMISTRY MONITORING

Water column chemistry monitoring was conducted monthly at Prompton Reservoir from May to October 2002 (except in September; Table 2-1). Water samples were collected at four fixed stations within the reservoir watershed (Fig. 2-1). Surface water samples were collected at stations upstream (PR-1) and downstream (PR-4) of the reservoir. Surface, middle, and bottom water samples were collected at main reservoir stations (PR-2 and PR-3). Surface water samples were collected by opening the sample containers approximately 1 foot below the water's surface. Middle and bottom water samples were collected with a Van Dorn design horizontal water bottle or submersible purge pump.

Water samples from all depths were analyzed for ammonia, nitrite, nitrate, total Kjeldahl nitrogen (TKN), dissolved phosphate, total phosphorus, total dissolved phosphorus, total dissolved solids (TDS), total suspended solids (TSS), biochemical oxygen demand (BOD), alkalinity, and chlorophyll *a*. A new parameter, hydrogen sulfide was monitored this year at station PR-4. Table 2-2 summarizes the water quality parameters, laboratory methods, detection limits, state water quality standards, and allowable and achieved maximum hold times for each during the 2002 monitoring period.

Table 2-1. Prompton Reservoir water quality monitoring schedule for 2002

Date of Sample Collection	Physical Stratification Monitoring (All Stations)	Water Column Chemistry Monitoring (All Stations)	Trophic State Determination (PR-2 and PR-3)	Coliform Bacteria Monitoring (All Stations)	Sediment Priority Pollutant Monitoring (PR-3)	Drinking Water Monitoring*
21 May	X	X	X	X		
19 June	X	X	X	X		Set A and B
23 July	X	X	X	X	X	
20 August	X	X	X	X		Set A
2 October	X	X	X	X		

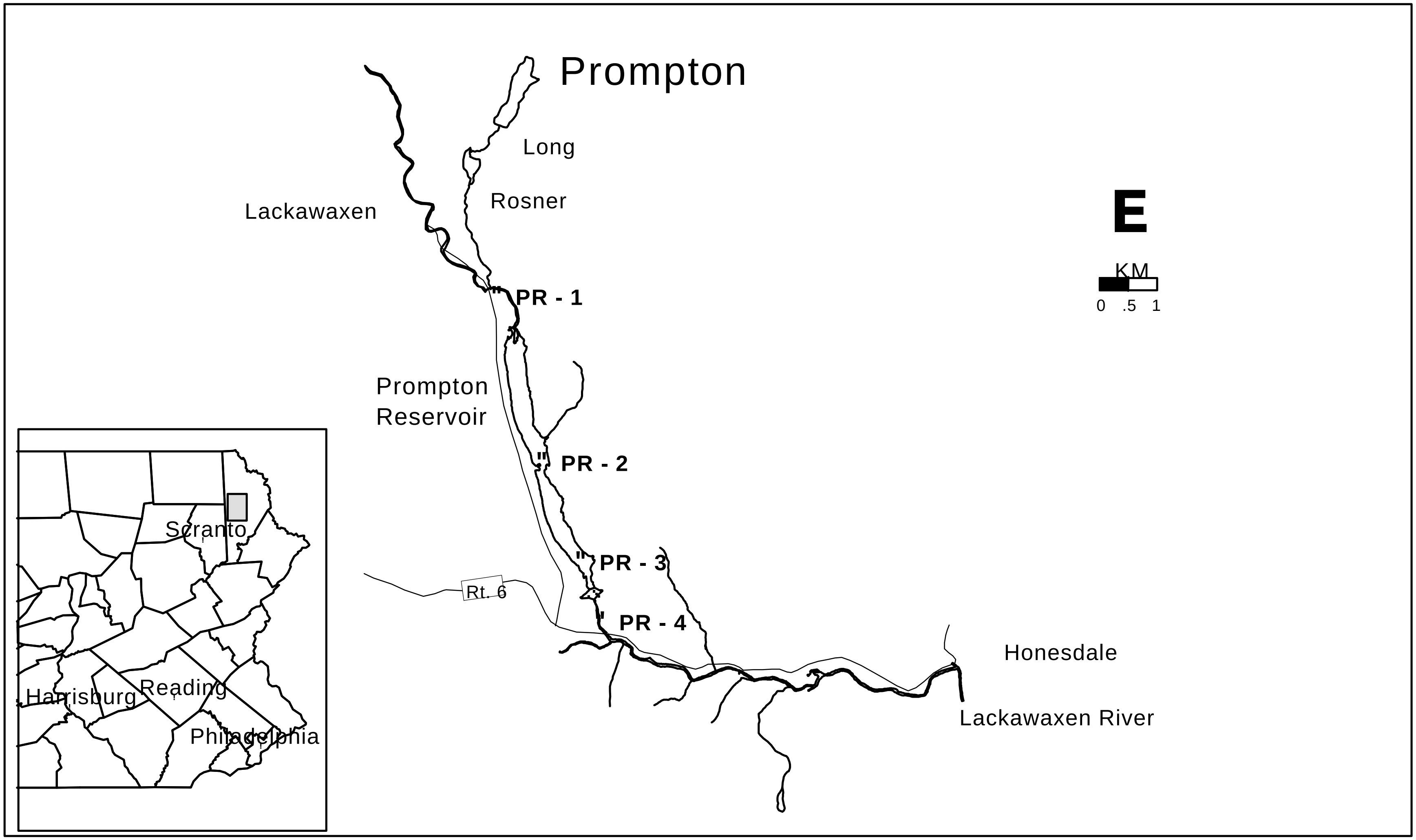

Figure 2-1. Location map for Prompton Reservoir and water quality monitoring stations in 2002

Table 2-2. Water quality test methods, detection limits, state regulatory criteria, and sample holding times for water quality parameters monitored at Prompton Reservoir in 2002.

Parameter	EPA Method	Detection Limit	PADEP Surface Water Regulatory Criteria	Allowable Hold Times (Days)	Maximum Hold Time Achieved
Alkalinity	310.1	1 mg/L	Minimum 20 mg/L $CaCO_3$	14	13
Biochemical Oxygen Demand (BOD)	SM5210B	2 mg/L	None	2	2
Total Phosphorus	365.2	0.01 mg/L	None	28	8
Total Dissolved Phosphorus	365.2	0.01 mg/L	None	28	9
Dissolved Phosphate	365.2	0.01 mg/L	None	28	9
* Chlorophyll *a*			None		3
Total Kjeldahl Nitrogen	351.3	0.10 mg/L	None	28	14
Ammonia	350.3	0.05 mg/L	Temperature and pH dependent	28	13
Nitrate	353.2	0.1 mg/L	Maximum 10 mg/L (nitrate + nitrite)	2	2
Nitrite	354.1	0.01 mg/L		2	2
Total Dissolved Solids	160.1	10 mg/L	Maximum 750 mg/L	7	6
Total Suspended Solids	160.2	1 mg/L	None	7	6
Hydrogen Sulfide	376.1	0.4 mg/L	None	7	5

* Chlorophyll *a* samples were calculated by averaging 10 readings per minute using a YSI 6600 with a chlorophyll sensor.

2.3 TROPHIC STATE DETERMINATION

The trophic state of Prompton Reservoir was determined by methods outlined by Carlson (1977). In general, this method calculates trophic state indices (TSIs) independently for measures of total phosphorus, chlorophyll *a*, and secchi disk depth. Surface water measures of total phosphorus and chlorophyll *a* from chemistry monitoring were averaged in the calculations of monthly TSIs (Table-2-1). Secchi disk depth was measured monthly at stations PR-2 and PR-3 and similarly averaged for the TSI calculation. Trophic state determinations were made using criteria defined by Carlson (1977) and EPA (1983).

2.4 RESERVOIR BACTERIA MONITORING

Monitoring for coliform bacteria contaminants was conducted monthly for May to October 2002 at Prompton Reservoir. Surface water samples were collected in the same manner as for chemical parameter samples, and analyzed for total coliform, fecal coliform and fecal streptococcus contamination. Table 2-3 presents the test methods, detection limits, PADEP standards, and sample holding times for the bacteria parameters monitored at Prompton Reservoir in 2002. The bacteria analytical method was based on a membrane filtration technique. All of the samples were analyzed within their maximum allowable hold times. At the end of the monitoring period, streamflow data collected from a USGS gauging station in the region (Aldenville) and precipitation data collected at the dam were used to correlate rainfall patterns with measured bacteria levels (see Section 2.5).

Table 2-3. Water quality test methods, detection limits, PADEP standards, and sample holding times for bacteria parameters monitored at Prompton Reservoir in 2002

Parameter	**Total coliform**	**Fecal coliform**	**Fecal Streptococcus**
Test method	SM 9222B	SM9222D	SM9230C
Detection limit	10 clns/100-mls	10 clns/100-mls	10 clns/100-mls
PADEP standard	-	Geometric Mean < 200 clns/100-mls (application of this standard is conservative because swimming is not permitted in the reservoir)	-
Maximum allowable holding time	30 hours	30 hours	30 hours
Achieved holding time	< 30 hours	< 30 hours	< 30 hours

Monthly coliform bacteria counts were compared to the PADEP water quality standard for bacteria. The standard is defined as a maximum geometric mean of 200 colonies/100-ml based on five samples collected on different days. Given our logistical limitations (all monthly sampling conducted on one day), we calculated the geometric mean based on all of the surface samples collected for each month. Although our sampling design does not fully meet PADEP guidelines, we feel that this interpretation of the coliform data meets the intent of the PADEP water quality standard for evaluating Prompton Reservoir bacteria levels. Additionally, application of this standard is conservative because swimming and other human/water contact recreation is prohibited in the reservoir.

2.5 STREAMFLOW AND PRECIPITATION DATA

Streamflow and precipitation data for the principal monitoring months from May to October were compiled from USACE records (Figs. 2-2 through 2-7). Streamflow and precipitation data was collected from the USGS station located in Aldenville and reflects rainfall patterns throughout the Prompton Reservoir watershed. Monthly monitoring on 21 May was collected at a baseflow of approximately 141-cfs (Fig.2-2). Baseflow decreased throughout the monthly sampling events from June through August. Monthly monitoring was collected on 19 June at baseflow of approximately 77-cfs (Fig.2-3). During the July sampling there was a rainfall of 0.51 inches, but the stream flow was still at a low level of approximately 12-cfs (Fig.2-4). In August (Fig.2-5), the baseflow decreased to approximately 7-cfs. Baseflow continued to decrease until September 22, when there was small rain event of 0.84 inches (Fig.2-6). After this storm event and another larger one on September 27, baseflow began to slowly increase. October sampling was conducted at a baseflow of approximately 24-cfs (Fig.2-7).

2.6 SEDIMENT PRIORITY POLLUTANT MONITORING

Sediment from Prompton Reservoir was monitored for priority pollutant contaminants, Group 1 –PCB's, pesticides, and volatile organic compounds. Sediment was collected on 23 July at station PR-3 with a petite ponar grab-sampler. Sediment from the grab-sampler was emptied into a stainless steel mixing bowl homogenized with a stainless steel spoon. Sediments were contained in appropriately labeled sample jars and stored on ice until shipment to the analytical laboratory. All field equipment used during the handling of reservoir sediments was decontaminated prior to sampling. Decontamination procedures were as follows: detergent wash, first deionized water rinse, 10% nitric acid rinse, second deionized water rinse, hexane rinse, and third deionized water rinse. Table 2-4 summarizes the parameters monitored, method detection limits, sample hold times, and the laboratory methods used in the analyses.

All sediment contaminant concentrations were reported on a dry weight basis, and were calculated as follows:

$$\text{Dry weight concentration (mg/kg)} = \frac{\text{Wet weight concentration (mg/kg)} \times 100}{\text{Sample percent solids}}$$

Sample-specific detection limits were calculated for the sediment tests because of matrix interference and the conversion from wet weight to dry weight.

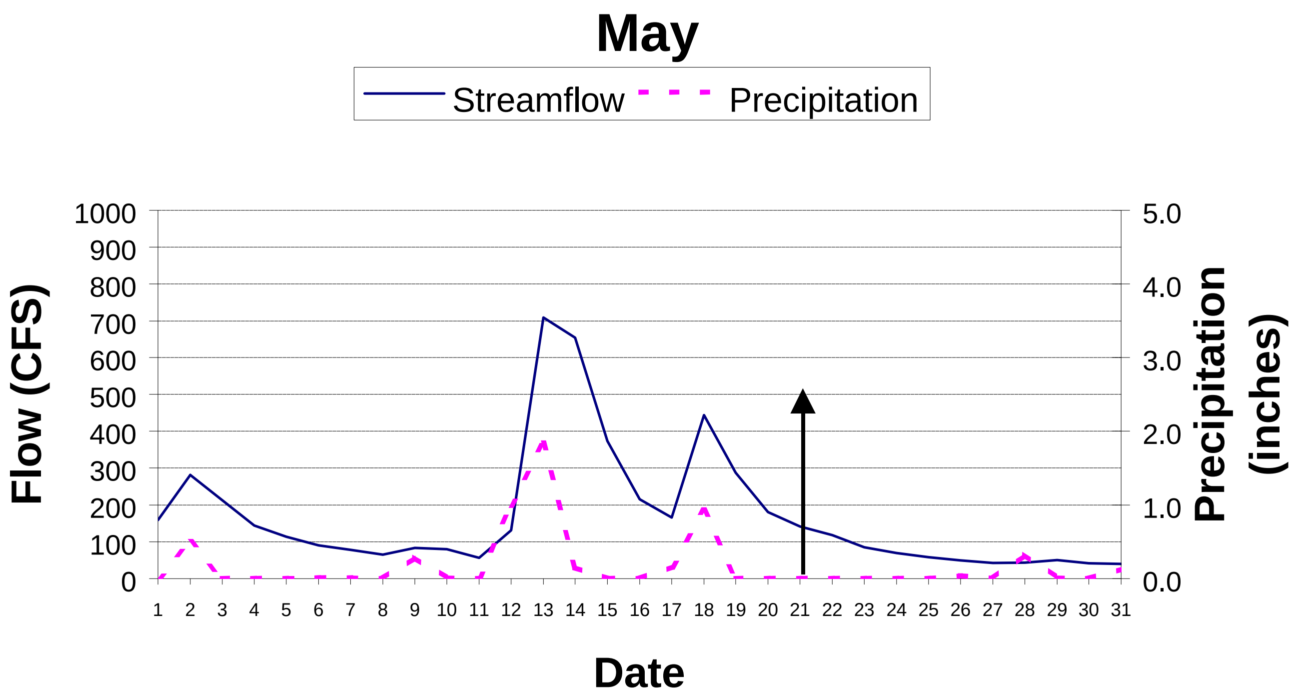

Figure 2-2. May streamflow and precipitation in the vicinity of Prompton Reservoir during 2002.

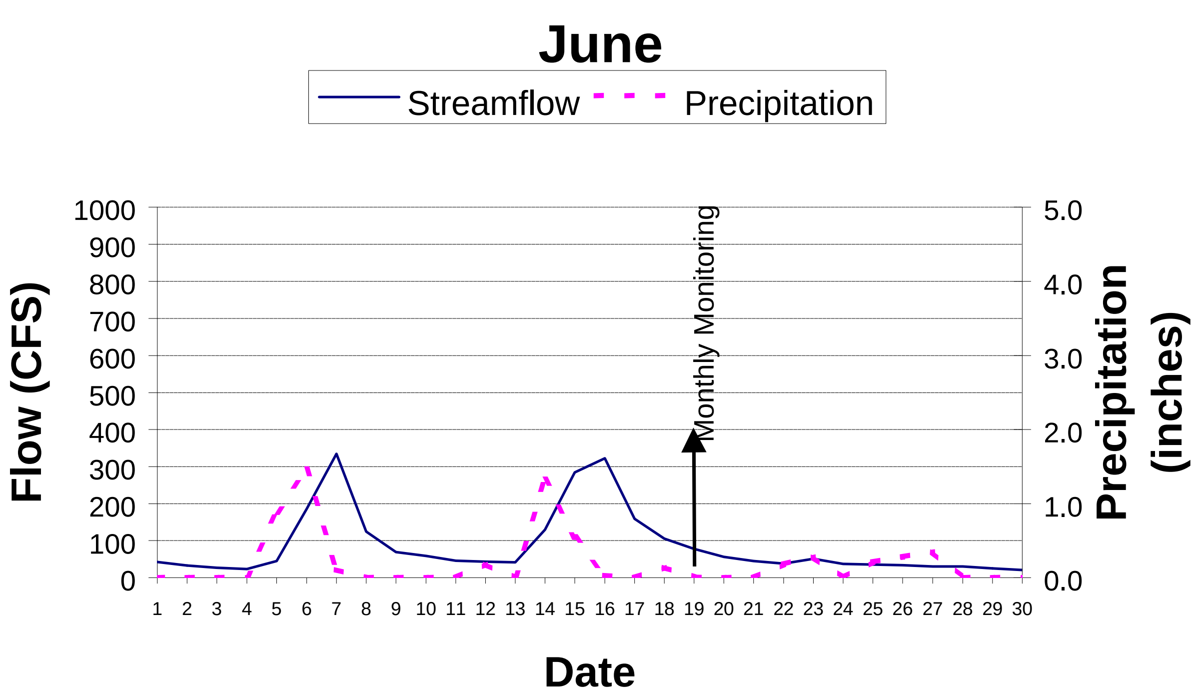

Figure 2-3. June streamflow and precipitation in the vicinity of Prompton Reservoir during 2002.

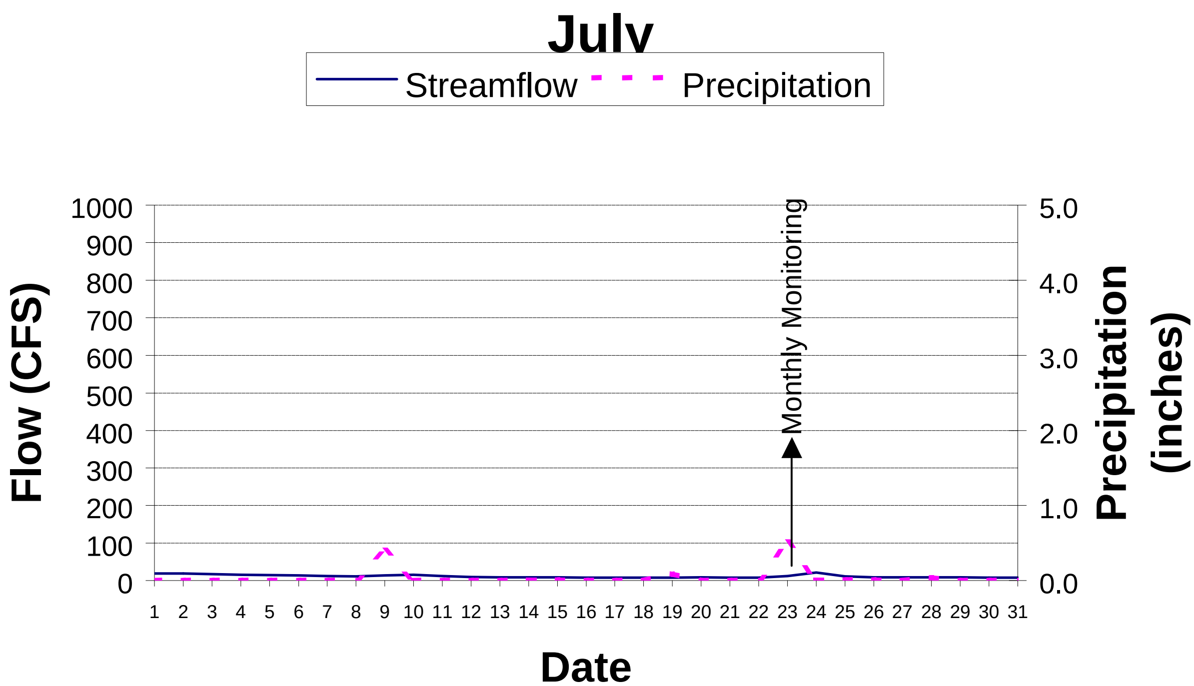

Figure 2-4. July streamflow and precipitation in the vicinity of Prompton Reservoir during 2002.

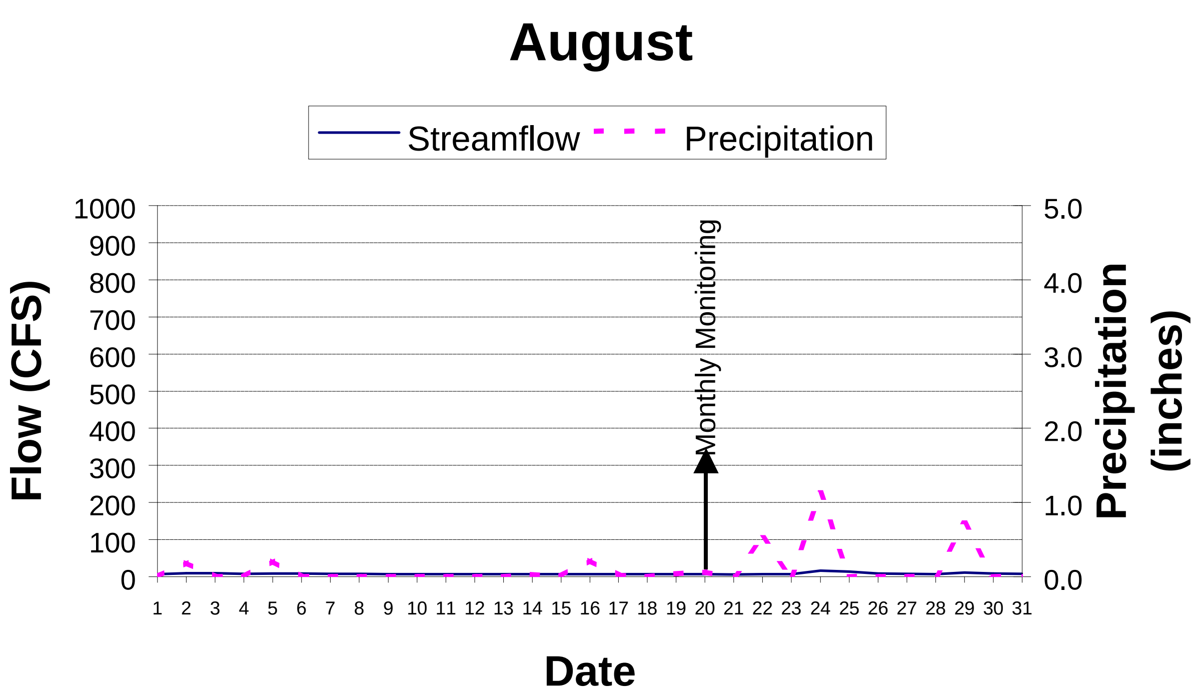

Figure 2-5. August streamflow and precipitation in the vicinity of Prompton Reservoir during 2002.

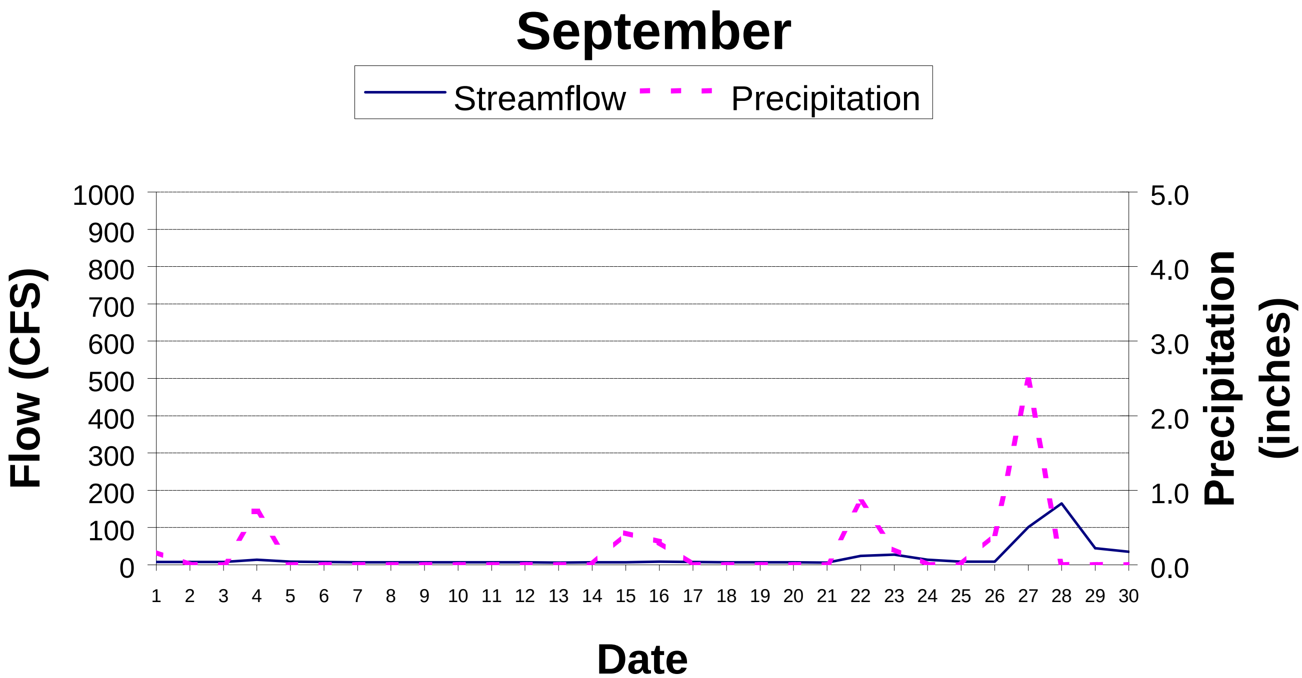

Figure 2-6. September streamflow and precipitation in the vicinity of Prompton Reservoir during 2002

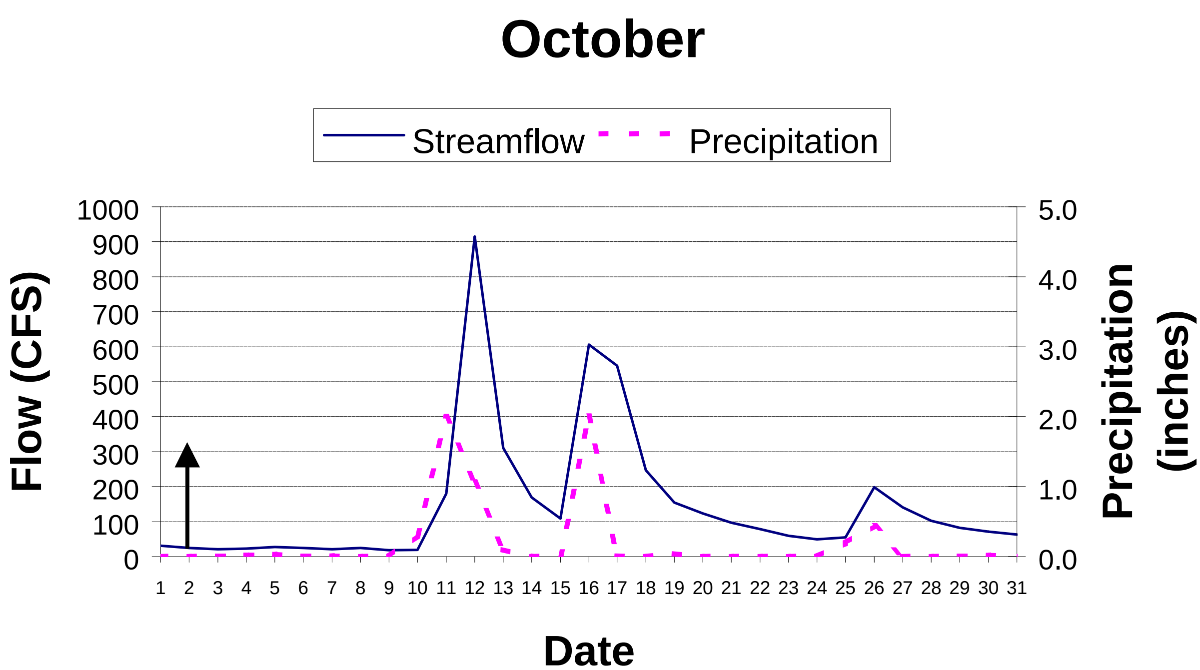

Figure 2-7. October streamflow and precipitation in the vicinity of Prompton Reservoir during 2002

Table 2-4. Sediment priority pollutants, Group 1 –volatile organic compounds, PCB's, and pesticides monitored at Prompton Reservoir during 2002.

Parameter	Units	Method Detection Limit BM-6
PCBs - Method 8082		
Aroclor-1016	ppb	8929
Aroclor-1221	ppb	8929
Aroclor-1232	ppb	8929
Aroclor-1242	ppb	8929
Aroclor-1248	ppb	8929
Aroclor-1254	ppb	8929
Aroclor-1260	ppb	8929
Pesticides - Method 8081A		
4,4'-DDD	ppb	357
4,4'-DDE	ppb	357
4,4'-DDT	ppb	357
alpha-BHC	ppb	357
a-Chlordane	ppb	357
Aldrin	ppb	357
beta-BHC	ppb	357
Chlordane, technical	ppb	3571
delta-BHC	ppb	357
Dieldrin	ppb	357
Endosulfan I	ppb	357
Endosulfan II	ppb	357
Endrin	ppb	357
Endrin aldehyde	ppb	357
Endrin ketone	ppb	357
Endosulfan Sulfate	ppb	357
gamma-BHC (Lindane)	ppb	357
g-Chlordane	ppb	357
Heptachlor	ppb	357
Heptachlor epoxide	ppb	357
Methoxychlor	ppb	893
Toxaphene	ppb	17857
Volatile Organic Compounds - Method 8260B		
1,1,1,2-Tetrachloroethane	ppb	356
1,1,1-Trichloroethane	ppb	356
1,1,2,2-Tetrachloroethane	ppb	356
1,1,2-Trichloroethane	ppb	356
1,1-Dichloroethane	ppb	356
1,1-Dichloroethene	ppb	356
1,1-Dichloropropene	ppb	356
1,2,3-Trichlorobenzene	ppb	356
1,2,3-Trichloropropane	ppb	356

Table 2-4. (Continued)		
Parameter	**Units**	**Method Detection Limit BM-6**
Volatile Organic Compounds - Method 8260B (Continued)		
1,2,4-Trichlorobenzene	ppb	356
1,2,4-Trimethylbenzene	ppb	356
1,2-Dibromo-3-chloropropane	ppb	356
1,2-Dichloroethane	ppb	356
1,2-Dichlorobenzene	ppb	356
1,2-Dichloropropane	ppb	356
1,2-Dibromoethane	ppb	356
1,3,5-Trimethylbenzene	ppb	356
1,3-Dichlorobenzene	ppb	356
1,3-Dichloropropane	ppb	356
1,4-Dichlorobenzene	ppb	356
2,2-Dichloropropane	ppb	356
2-Chlorotoluene	ppb	356
2-Hexanone	ppb	3560
4-Chlorotoluene	ppb	356
Acetone	ppb	3560
Benzene	ppb	356
Bromochloromethane	ppb	356
Bromodichloromethane	ppb	356
Bromobenzene	ppb	356
Bromoform	ppb	356
Bromomethane	ppb	356
c-1,2-Dichloroethene	ppb	356
c-1,3-Dichloropropene	ppb	356
Carbon Tetrachloride	ppb	356
Chlorobenzene	ppb	356
Chloroethane	ppb	356
Chloroform	ppb	356
Chloromethane	ppb	356
Methylene Chloride (DCM)	ppb	406
Dibromochloromethane	ppb	356
Dibromomethane	ppb	356
Dichlorofluoromethane	ppb	356
Ethylbenzene	ppb	356
Hexachloro1,3-butadiene	ppb	356
Isopropylbenzene (cumene)	ppb	356
m,p-Xylene	ppb	356
2-Butanone(MEK)	ppb	3560
4-Methyl-2-pentanone (MIBK)	ppb	3560
Methyl-tert-butylether (MTBE)	ppb	356
n-ButylBenzene	ppb	356

Table 2-4. (Continued)		
Parameter	**Units**	**Method Detection Limit BM-6**
Volatile Organic Compounds - Method 8260B (Continued)		
n-Propylbenzene	ppb	356
Naphthalene	ppb	356
o-Xylene	ppb	356
p-Isopropyltoluene	ppb	356
Tetrachloroethene	ppb	356
sec-Butylbenzene	ppb	356
Styrene	ppb	356
t-1,2-Dichloroethene	ppb	356
t-1,3-Dichloropropene	ppb	356
t-Butylalcohol	ppb	3560
Trichloroethene	ppb	356
Toluene	ppb	356
Trichlorofluoromethane	ppb	356
Vinyl chloride	ppb	356

2.7 TREND ANALYSIS METHODS

Annual water quality, sediment contaminant, and drinking water monitoring have been conducted at Prompton Reservoir since 1975. Data collected over these years were compiled into an electronic database by the USACE (Versar 1996). The historical database enables the use of statistical trend analysis, an important step toward understanding how the water quality of Prompton Reservoir is changing. A number of trend analysis methods are available, some more complicated than others. For the purpose of this report, we employed two general methods, regression and the Mann-Kendall, or Seasonal Kendall, test.

2.7.1 Regression Analysis

The spatial and temporal distributions of the historical data were examined to determine which stations and parameters had sufficient time series to warrant meaningful trend analysis. For the major water quality parameters (e.g., nutrients, dissolved oxygen, total dissolved solids) downstream station PR-4 and reservoir station PR-2 were consistently sampled over the time series. Water quality trend analyses were limited to the spring (April through June) and summer (July through October) periods. The "spring season" analyses were conceptualized as representing long-term changes associated with inputs to the reservoir system during snow melt periods. The "summer season" analyses depicted conditions during periods of maximum potential productivity and greatest low DO stress. Trends at station PR-4 were analyzed separately to evaluate conditions downstream of the dam. Water quality trends within the reservoir were evaluated using concentrations observed at station PR-2.

Regression analyses were used to determine if significant increases or decreases in parameter concentrations occurred during the time series. The slope of the regression line was used to estimate the yearly rate of change. For this report, regression analysis was applied to the following water quality parameters: total nitrogen, total phosphorus, total dissolved solids, biochemical oxygen demand, and fecal coliform.

2.7.2 Mann-Kendall Analysis

In addition to the regression analysis, the non-parametric Mann-Kendall test was used to determine trends for individual stations over the time span of historical monitoring at Prompton Reservoir. The Mann-Kendall test (or Seasonal Kendall test) scores all combinations of yearly changes for the tested parameter with a +1 or -1 depending on whether parameter concentrations increased or decreased over the time interval. All of the scores are then summed and compared to the Chi-Square distribution to determine if the parameter had a significant trend (increasing or decreasing) over the time series. For this report, the Mann-Kendall test was applied to the following water quality parameters: dissolved oxygen, ammonia, total nitrogen, total phosphorus, total dissolved solids, biochemical oxygen demand, and total and fecal coliform.

2.8 DRINKING WATER MONITORING

Drinking water was monitored from the utility sink in the maintenance building of Prompton Reservoir in 2002. Drinking water parameters were divided into two sets, A and B. Set A comprised bacteria parameters, total and fecal coliform (for analytical methods, see section 2.4), and nitrate and nitrite. Set A samples were collected on 19 June and 20 August (Table 2-1). Set B samples were analyzed for primary and secondary contaminants and were collected on 19 June. Table 2-5 summarizes the analytical methods, method detection limits, and sample hold times for each set B parameter. All of the drinking water quality parameters were analyzed within their respective maximum allowable hold times during 2002.

Table 2-5. Analytical methods, method detection limits and sample hold times for primary and secondary drinking water contaminants monitored at Prompton Reservoir in 2002.				
Parameter	**Detection Limits (mg/L)**	**Method**	**Allowable Hold Times (Days)**	**Maximum Hold Time Achieved (Days)**
Aluminum	0.003	200.7	183	9
Antimony	0.003	200.7	183	9
Arsenic	0.01	200.7	183	9
Barium	0.005	200.7	183	9
Cadmium	0.001	200.7	183	9
Chromium	0.001	200.7	183	9
Copper	0.001	200.7	183	9
Iron	0.002	200.7	183	9
Lead	0.003	200.7	183	9
Magnesium	0.001	200.7	183	9
Manganese	0.001	200.7	183	9
Mercury	0.0002	245.1	28	5
Nickel	0.001	200.7	183	9
Selenium	0.005	200.7	183	9
Silver	0.001	200.7	183	9
Sodium	0.02	200.7	183	9
Thallium	0.006	200.7	183	9
Zinc	0.003	200.7	183	9
Chloride	0.5	300	28	1
Cyanide, free	0.005	SM4500CN-I	14	6
Fluoride	0.1	300	28	1
Foaming Agents	0.01	SM5540C	2	1
Nitrate	0.05	300	2	2
Nitrite	0.01	300	2	2
pH	0.01	150.1	N/A	0
Sulfate	1.0	300	28	1
Total Dissolved Solids @ 180 ºC	10.0	160.1	7	2

3.0 RESULTS AND DISCUSSION

3.1 STRATIFICATION MONITORING

The following sections summarize the results of water quality monitoring for physical and chemical parameters: temperature, dissolved oxygen (DO), pH, and conductivity. For each parameter, we describe seasonal and spatial patterns of surface water quality measured throughout the watershed, and seasonal and depth related patterns of the stratified water column based on measures from the deepest portion of the reservoir (station PR-3). We feel that it is appropriate to focus discussion of stratification on station PR-3 as water quality problems related to depth are generally most severe in deeper water habitats, thus our evaluation will be a conservative one. Finally, we analyze 2002 data along with the Prompton Reservoir historical database for trends in dissolved oxygen concentrations over the past decade. All of the physical/chemical parameters were measured with a calibrated Hydrolab water quality monitoring probe during stratification monitoring and are presented in Appendix Table A.

3.1.1 Temperature

Temperature of the surface waters of Prompton Reservoir followed a similar pattern during 2002. Temperatures at all monitoring stations were low in May, peaked in July and August, and dropping to about 18 °C in October (Fig. 3-1). The surface water temperature of the reservoir was generally greater than the upstream and downstream stations. Temperatures at reservoir body stations PR-2 and PR-3 averaged 20.3 °C and ranged from 9.7 °C in May to 27.0 °C in July and August. Reservoir body stations averaged 3.5 °C greater than the upstream (PR-1) and the downstream (PR-4) stations (Fig. 3-1). Upstream temperatures were generally coolest, and ranged from 6.7 to 21.4 °C throughout the monitoring period. Downstream temperatures were intermediate and most consistent during the summer months. Overall temperature at station PR-4 ranged from 11.1 to 21.4 °C.

Prompton Reservoir was stratified with respect to temperature in 2002 (Fig. 3-2). In June stratification became apparent with surface temperatures (19.3 °C) approximately 8 °C warmer than the lower water column (11.4 °C). This difference was more pronounced in July and August, as the surface had warmed to approximately 27 °C. During October, the temperature in the water column was fairly consistent only varying by 3 °C.

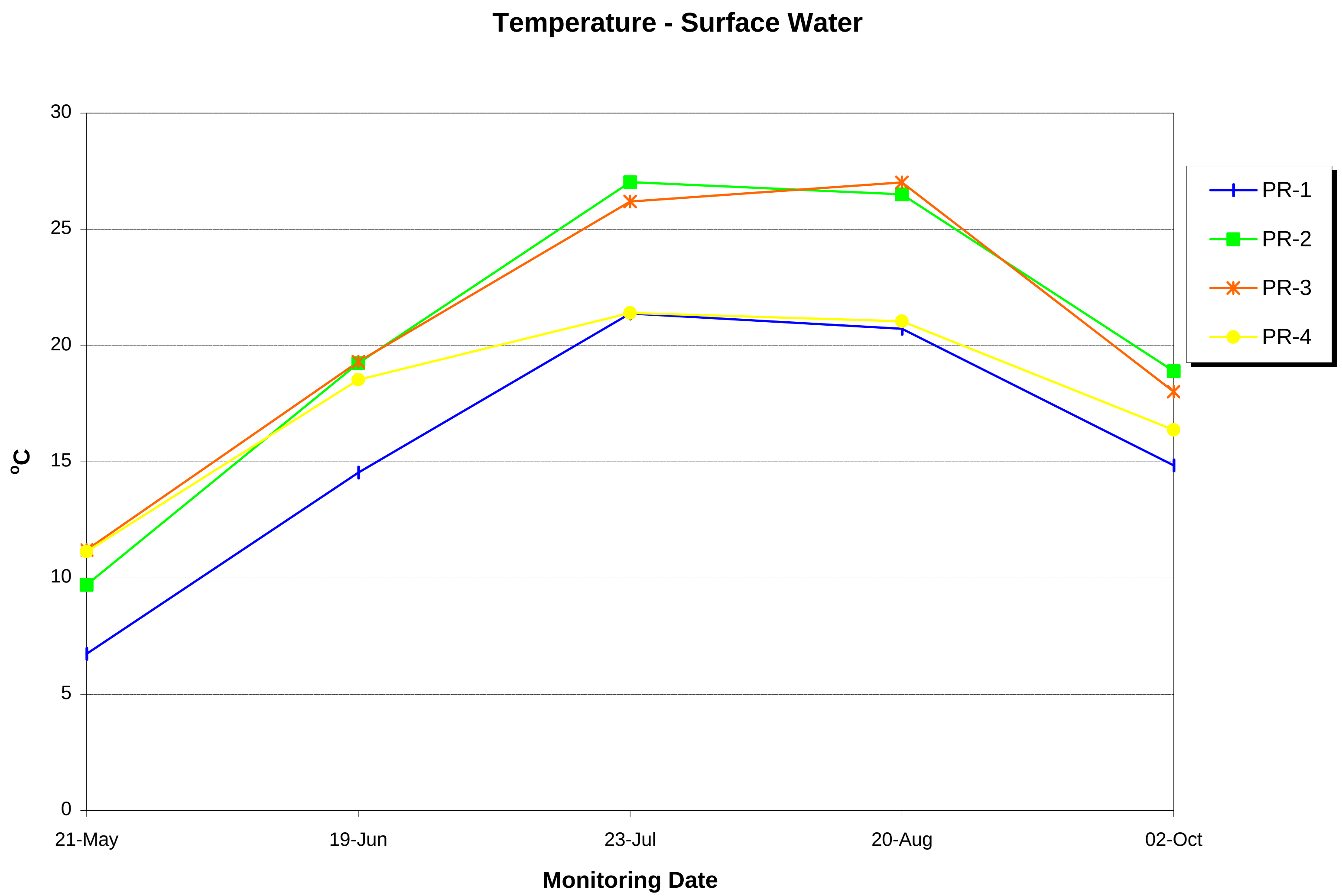

Figure 3-1. Temperature in surface water of Prompton Reservoir during 2002. See Appendix A for a summary of plotted values.

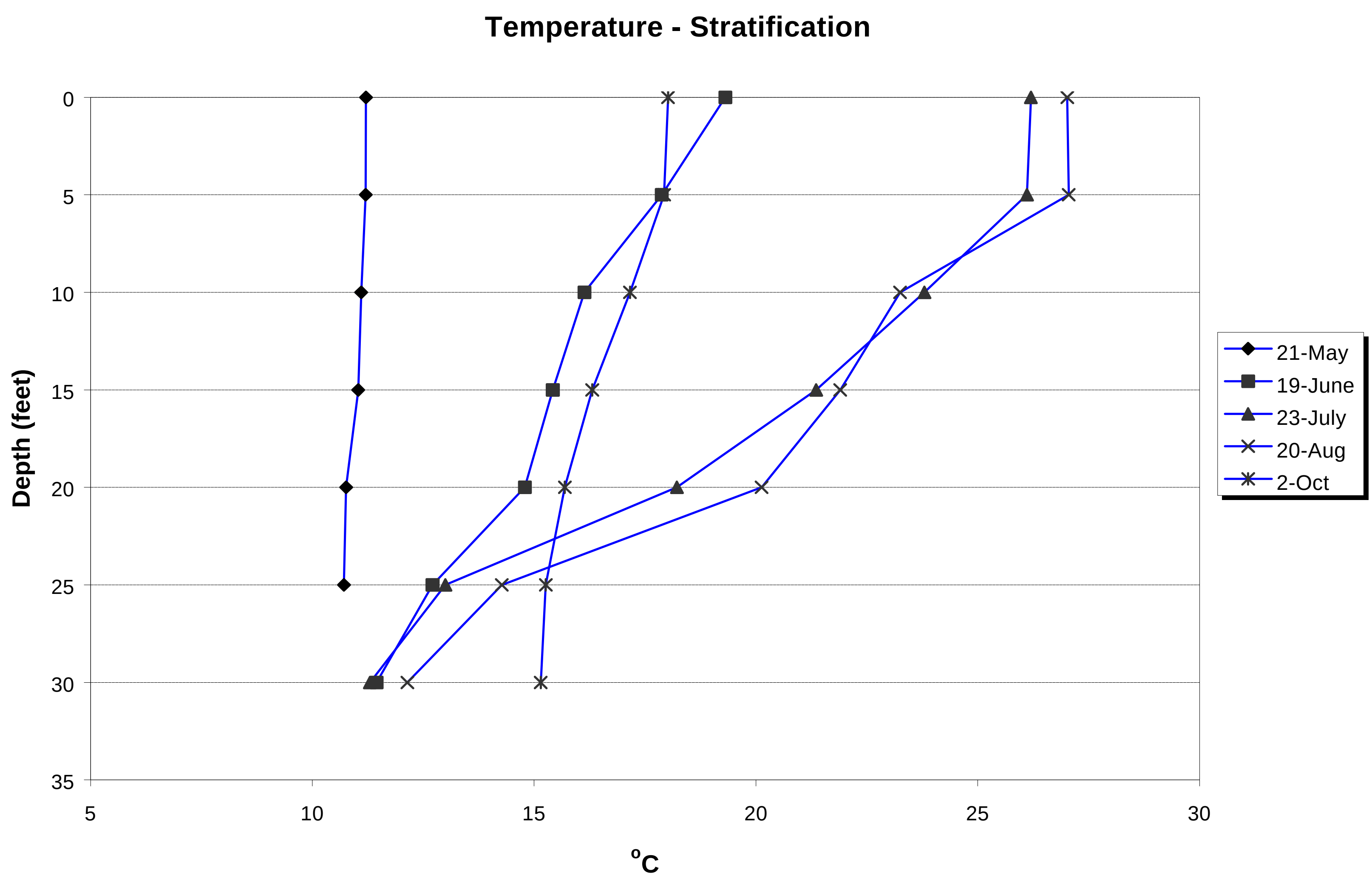

Figure 3-2. Temperature stratification of Prompton Reservoir during 2002 from water quality measured at station PR-3. See Appendix A for a summary of plotted values.

3.1.2 Dissolved Oxygen

Dissolved oxygen (DO) in the surface water generally followed a similar pattern throughout the watershed of Prompton Reservoir during 2002; however, differences were apparent between reservoir-body and upstream and downstream waters (Fig. 3-3). Stations located in the reservoir-body (PR-2 and PR -3) averaged 8.9-mg/L throughout the monitoring period. Dissolved oxygen concentrations downstream of the reservoir (PR-4) and at the upstream stations (PR-1) were slightly lower and averaged 8.2-mg/L.

The stratification of Prompton Reservoir dramatically influenced the distribution of DO in the water column during 2002 (Fig. 3-4). By June, the influence of stratification was apparent, as DO concentrations decreased from 8.3-mg/L at the surface to 0-mg/L at the bottom. By July and continuing into August, the lower water column from 10 feet to the bottom was severely depleted of oxygen with concentrations less then 2-mg/L. Surface concentrations in those months averaged approximately 8.2-mg/L. In October, concentrations of DO at the surface were 8.3-mg/L while concentrations of DO in the lower water column remained low.

DO concentrations in the water column of Prompton Reservoir were not in compliance with PADEP water quality standards from June to October. The Pennsylvania water quality standard for DO is a minimum concentration of 5 mg/L. In June, DO at station PR-3 from 10 feet to the bottom dropped below the standard. From July to October more than half of the water column was less than the standard.

The health of aquatic ecosystems can be impaired by low DO concentrations in the water column. Hypoxia, or conditions of DO concentrations less than 2 mg/L, is generally accepted as the threshold at which the most severe effects on biota occur. In 2002, the lower water column of Prompton was affected by hypoxia (Fig. 3-5). Hypoxic water was encountered from June through August and commonly occupied the lower half of the water column from 10 to 25-ft to the bottom. Hypoxia in the lower water column is a symptom of eutrophication. Nutrients in the water column feed explosive algal growth at the surface photic zone. Dead and decaying algae sink to lower levels of the water column and during the process of decay; oxygen is removed from the water column.

A seasonal trend analysis of DO was conducted for individual stations of Prompton Reservoir, combining 2002 and historical data. The Mann-Kendall statistic was applied to station data collected over the past 24 years or more, separately for spring (April to June) and summer (July to October) seasons. Stations included in the analysis represented upstream sources (PR-1) and the main reservoir (PR-2 and PR-3). Additionally, the downstream station (PR-4) was added recently using the previous seven years data. DO concentrations in the surface waters of Prompton Reservoir did not appear to be changing with consistency over the past two decades or at station PR-4. None of the trends were significant for any station or season in 2002 (Table 3-1).

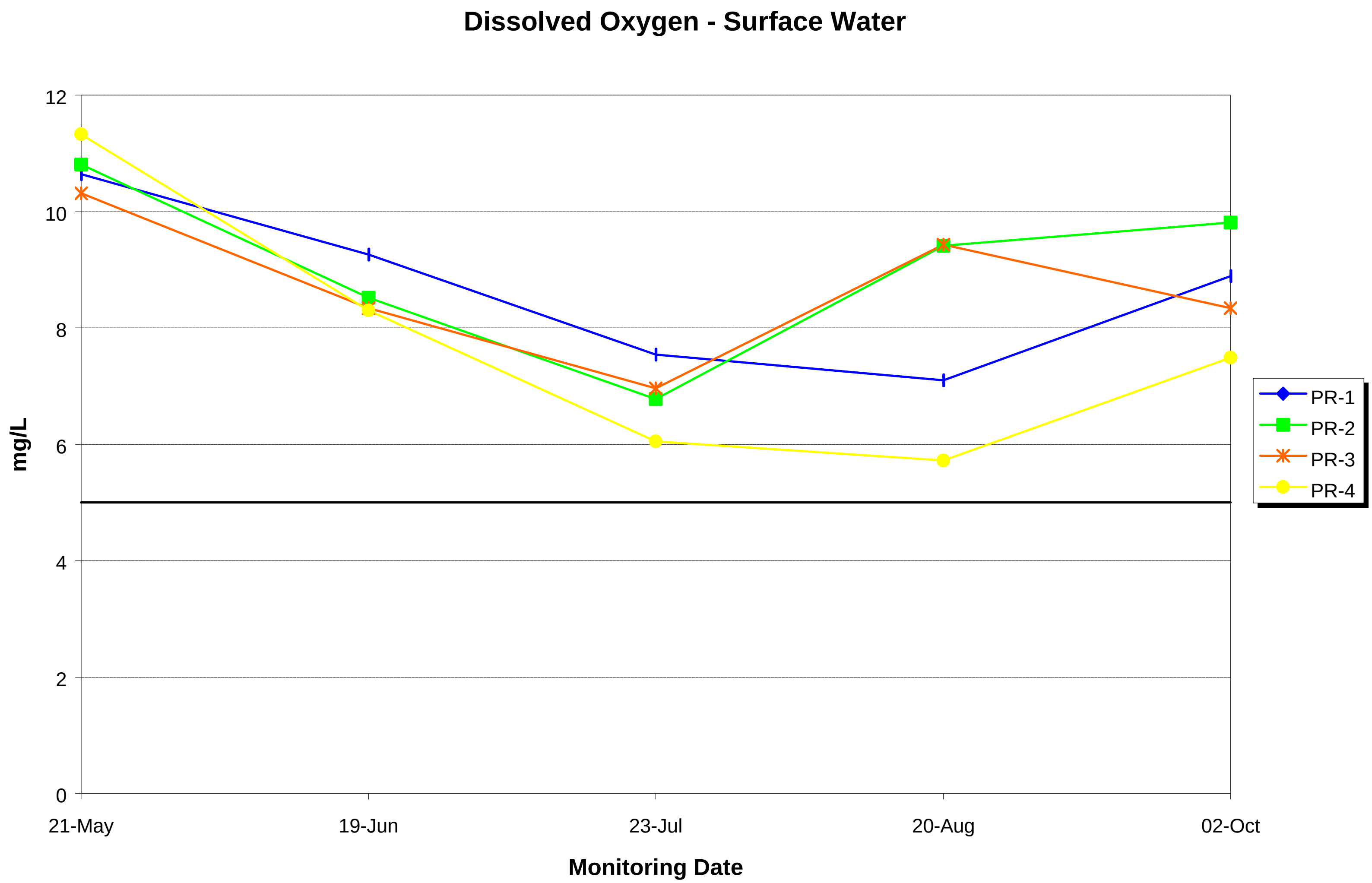

Figure 3-3. Dissolved oxygen in surface water of Prompton Reservoir during 2002. PADEP minimum DO standard is 5 mg/L. See Appendix A for a summary of plotted values.

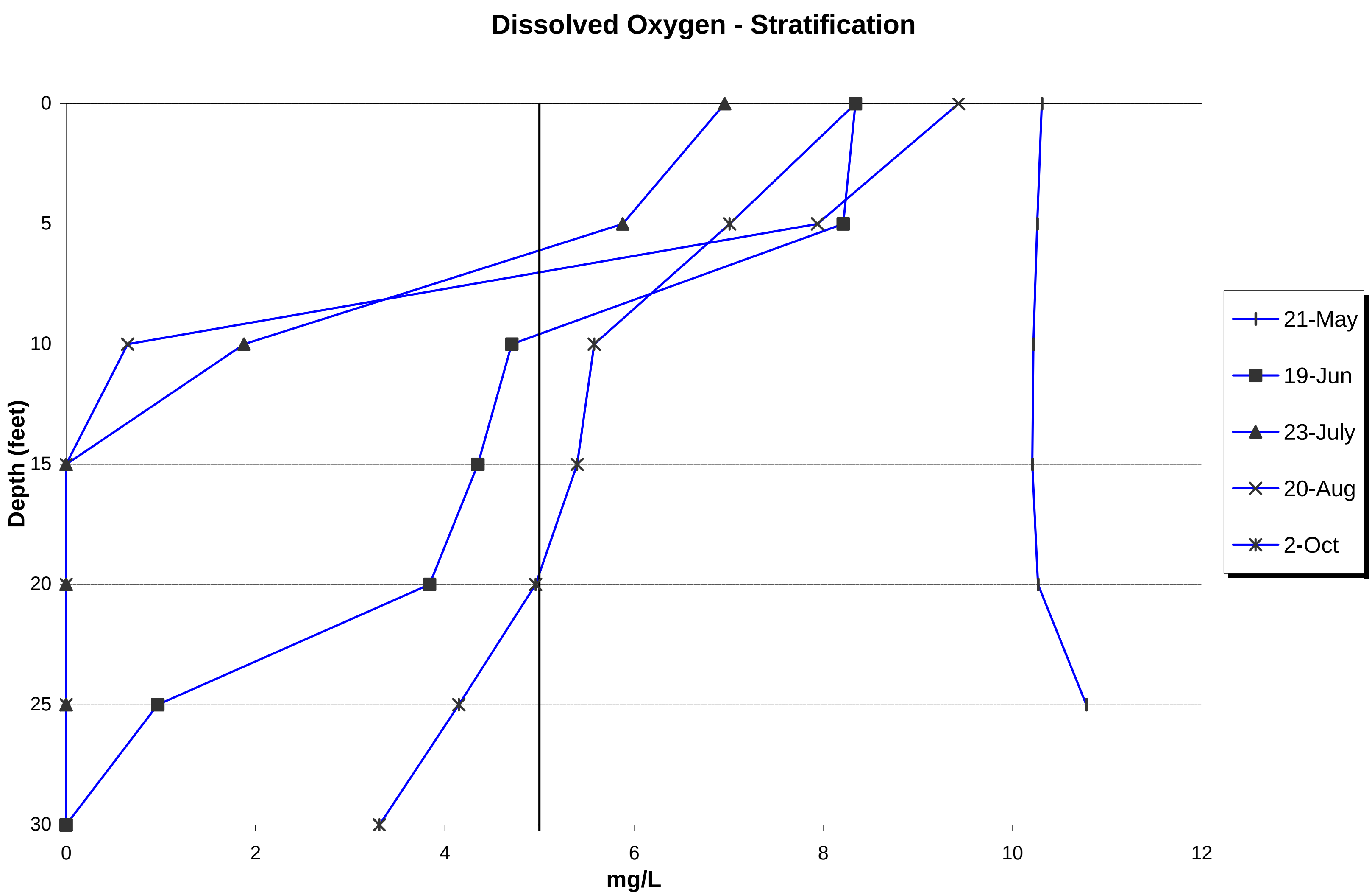

Figure 3-4. Dissolved oxygen stratification of Prompton Reservoir during 2002 from water quality measured at station PR-3. The PADEP minimum DO standard is 5 mg/L. See Appendix A for a summary of plotted values.

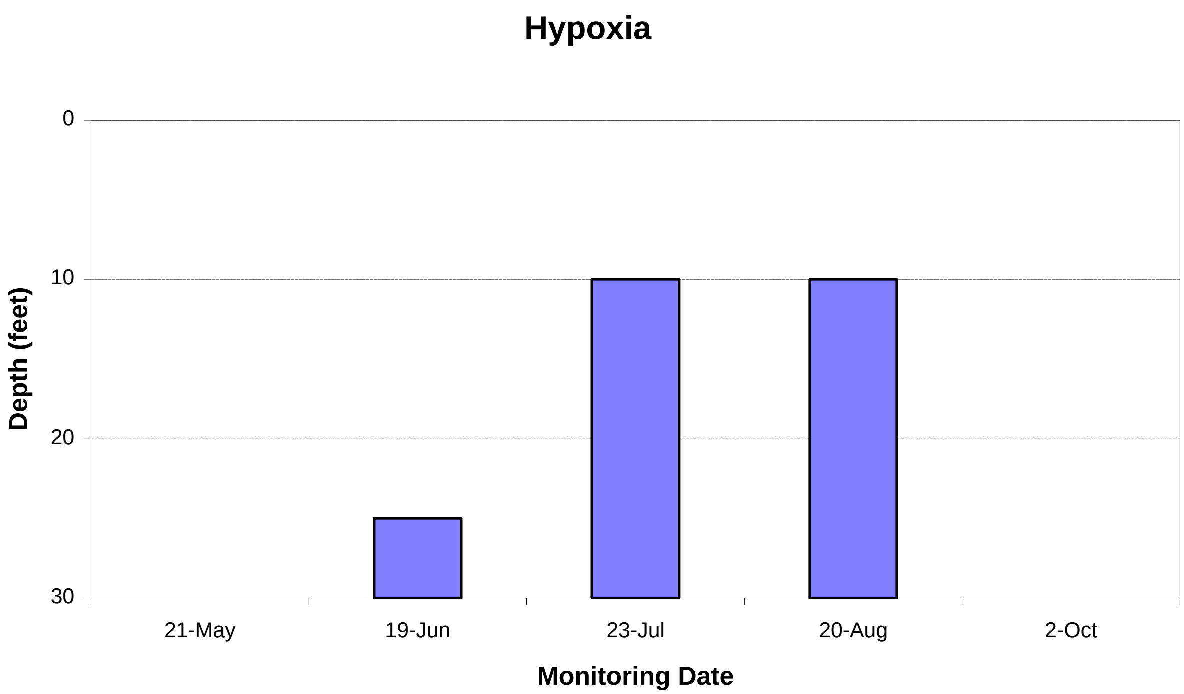

Figure 3-5. Spatial/temporal distribution of hypoxic reservoir water in Prompton Reservoir measured at station PR-3 in 2002. Histograms indicate dissolved oxygen concentrations in the water column below 2.0 mg/L.

Table 3-1. Seasonal trends of dissolved oxygen concentration at individual stations of Prompton Reservoir calculated with the Mann-Kendall Statistic.

Station	# of Years Spring/Summer	Spring		Summer	
		P Level	Rate (mg/L)	P Level	Rate (mg/L)
Surface Water					
PR-1	24	NS	0.0286	NS	-0.0238
PR-2	23/24	NS	0.0143	NS	-0.0058
PR-3	23/24	NS	0.0007	NS	0.0067
PR-4	7/8	NS	0.1108	NS	-0.1397

3.1.3 pH

Measures of pH in the surface waters of Prompton Reservoir generally followed two patterns during 2002. In the reservoir body, pH was variable throughout the monitoring period. At stations PR-2 and PR-3, pH was lowest in May with an average of 7.1 and greatest in August with an average of 9.6 (Fig. 3-6). The elevated pH in surface waters

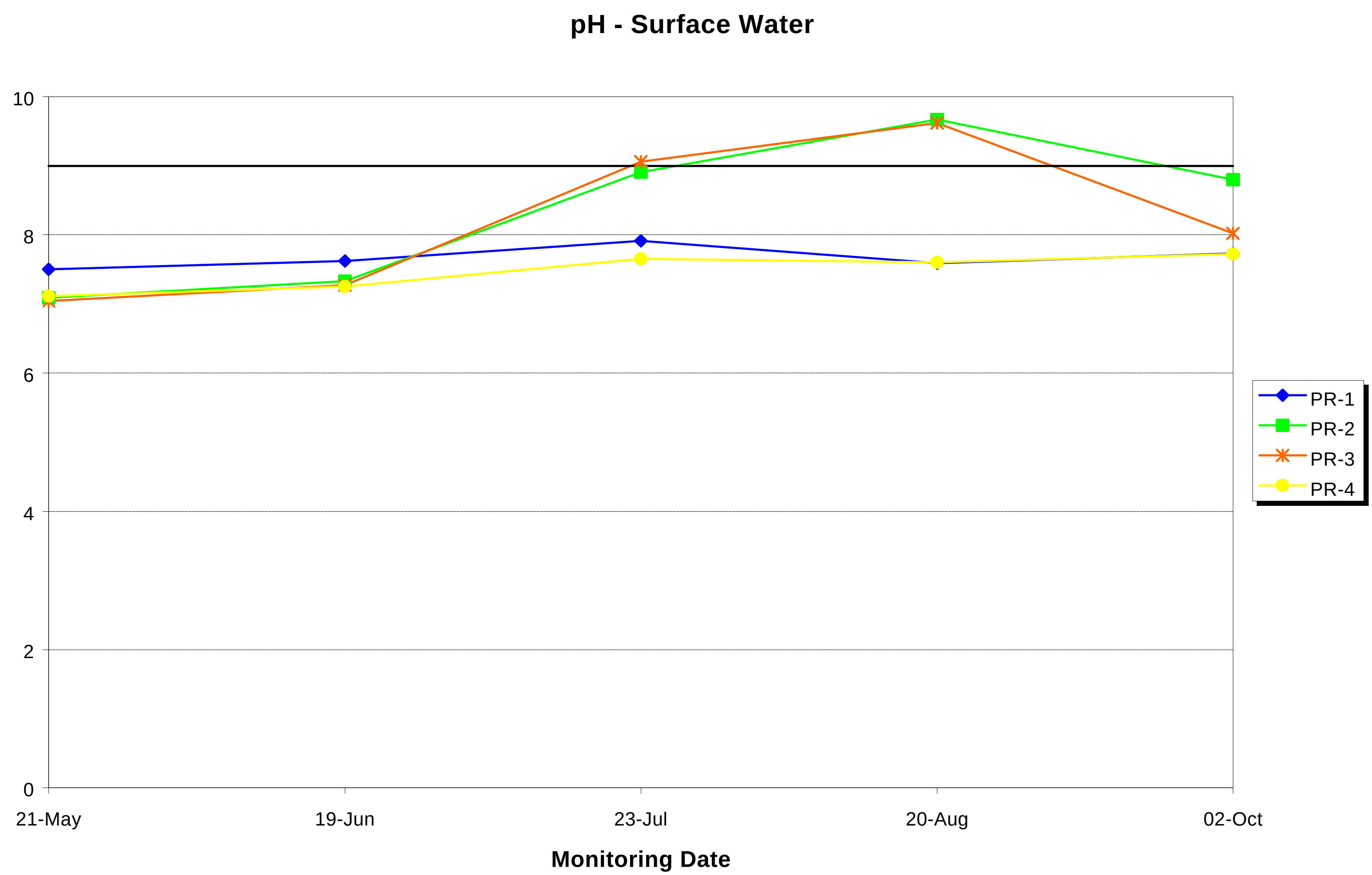

Figure 3-6. Measures of pH in surface waters of Prompton Reservoir during 2002. PADEP minimum and maximum pH standards are 6 and 9, respectively. See Appendix A for a summary of plotted values.

during summer periods is most likely due to algal blooms. As a function of increased productivity, algae remove CO_2 from the water column. Since dissolved CO_2 is slightly acidic, its reduction in the water column is manifested by an increase in pH. Measures of pH upstream and downstream of the reservoir were similar and uniform throughout the monitoring period. At stations PR-1 and PR-4 pH averaged about 7.6 from May through October (Fig. 3-6).

The water column of Prompton Reservoir was stratified with respect to pH in 2002. In general the development of stratification reflected an increase in pH at the surface while the lower water column remained relatively constant. In May, June, and October the water column was relatively uniform averaging 7.1, 6.9, and 7.5, respectively (Fig. 3-7). From July to August, the upper water column ranged as high as 9.6, while the water column below 10 feet averaged 7.2.

The water quality of Prompton Reservoir was at times not in compliance with PADEP standards for pH during 2002. The water quality standard for pH is a range of acceptability from 6 to 9. Measures of pH in surface water of Prompton Reservoir were greater than the standard range in August at station PR-3 (Fig. 3-7). All other measures of pH were in compliance with the water quality standard.

3.1.4 Conductivity

Conductivity in the surface waters of Prompton Reservoir was relatively stable during 2002. Conductivity measured at most stations remained uniform throughout the monitoring period, averaging 0.084-mS/cm (Fig. 3-8).

Prompton Reservoir was stratified with respect to conductivity during 2002. It appeared that the stratification pattern developed as conductivity increased in the lower water column while remaining largely uniform in the upper water column. In May, June, and October, the entire water column was mostly uniform at 0.08-mS/cm (Fig. 3-9). From July through August, the upper water column ranged from 0.08 to 0.1 mS/cm while the lower increased as high as 0.24 mS/cm. Increased conductivity in the deeper waters was probably an effect of the anoxic conditions present in July and August. In an anoxic environment, some metals (iron, manganese) are reduced and dissolve in the water column resulting in increased conductivity.

3.2 WATER COLUMN CHEMISTRY MONITORING

The following sections describe temporal, spatial, and depth related patterns for water quality parameters measured at Prompton Reservoir during 2002 (Table 3-2). Where appropriate, trends in surface water quality parameters are discussed incorporating 2002 data and the Prompton Reservoir water quality historical database.

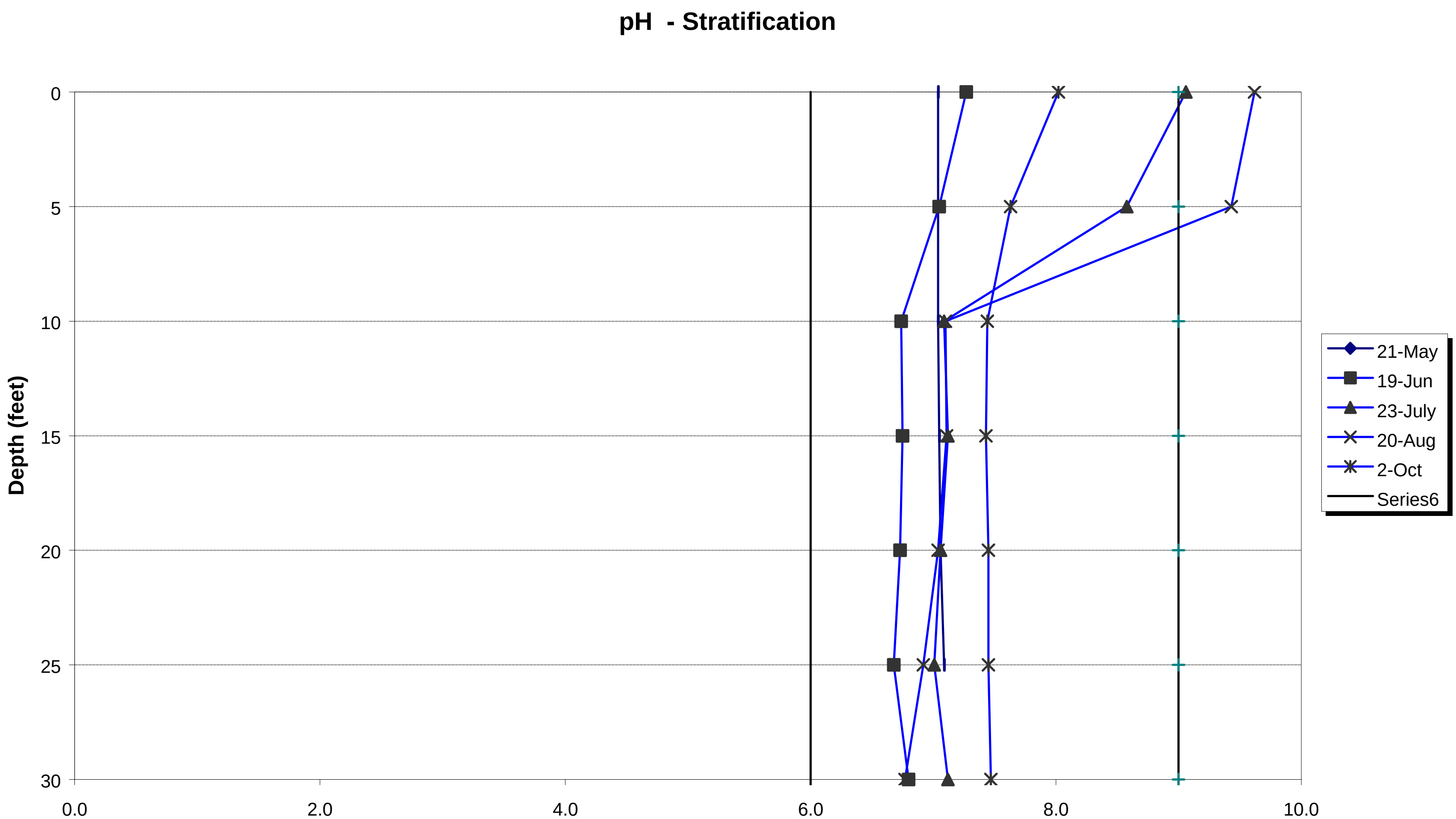

Figure 3-7. Stratification of pH at Prompton Reservoir during 2002, from water quality measured at station PR-3. PADEP minimum and maximum pH standards are 6 and 9, respectively. See Appendix A for a summary of plotted values.

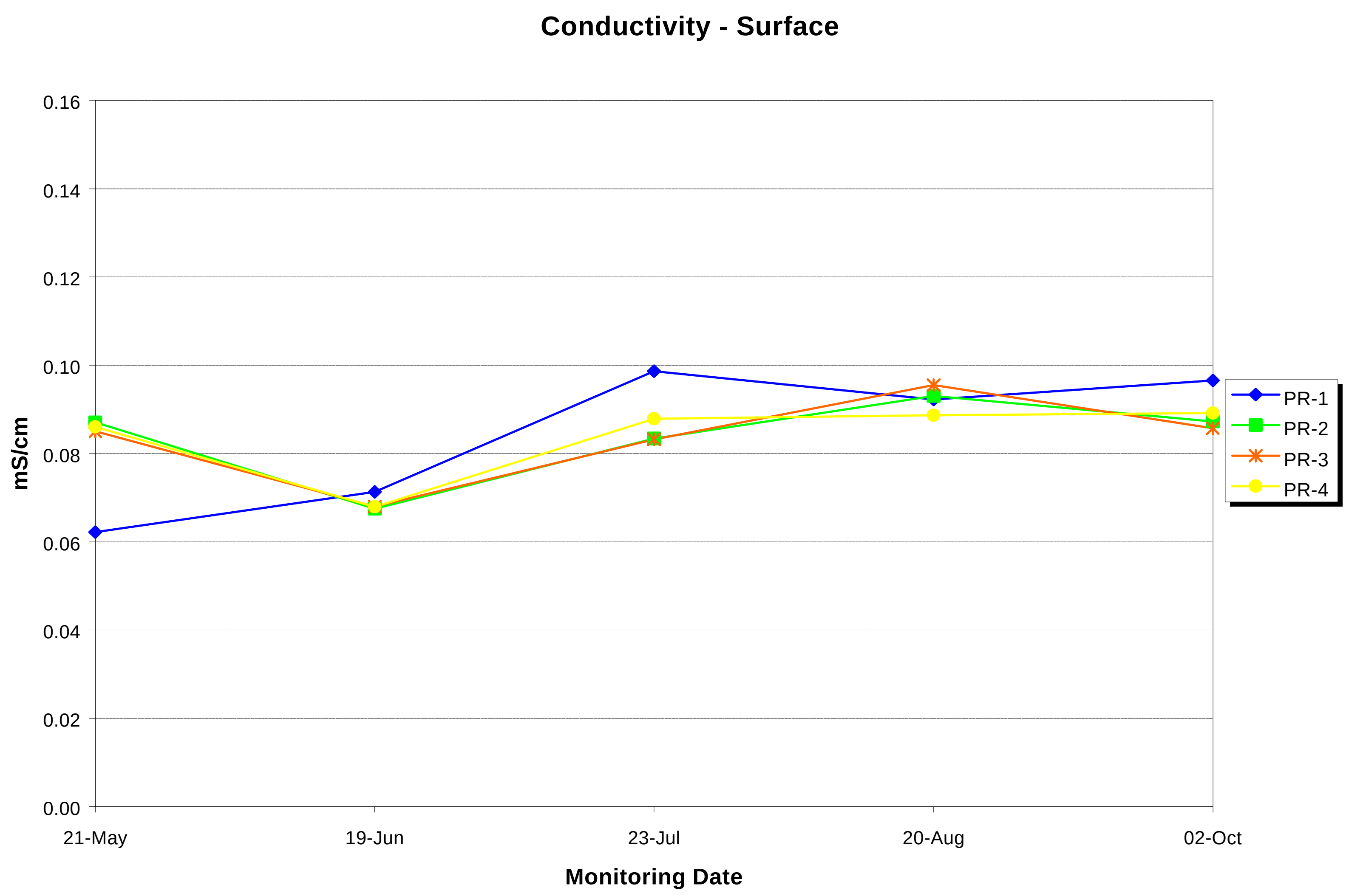

Figure 3-8. Conductivity in surface waters of Prompton Reservoir during 2002. See Appendix A for a summary of plotted values.

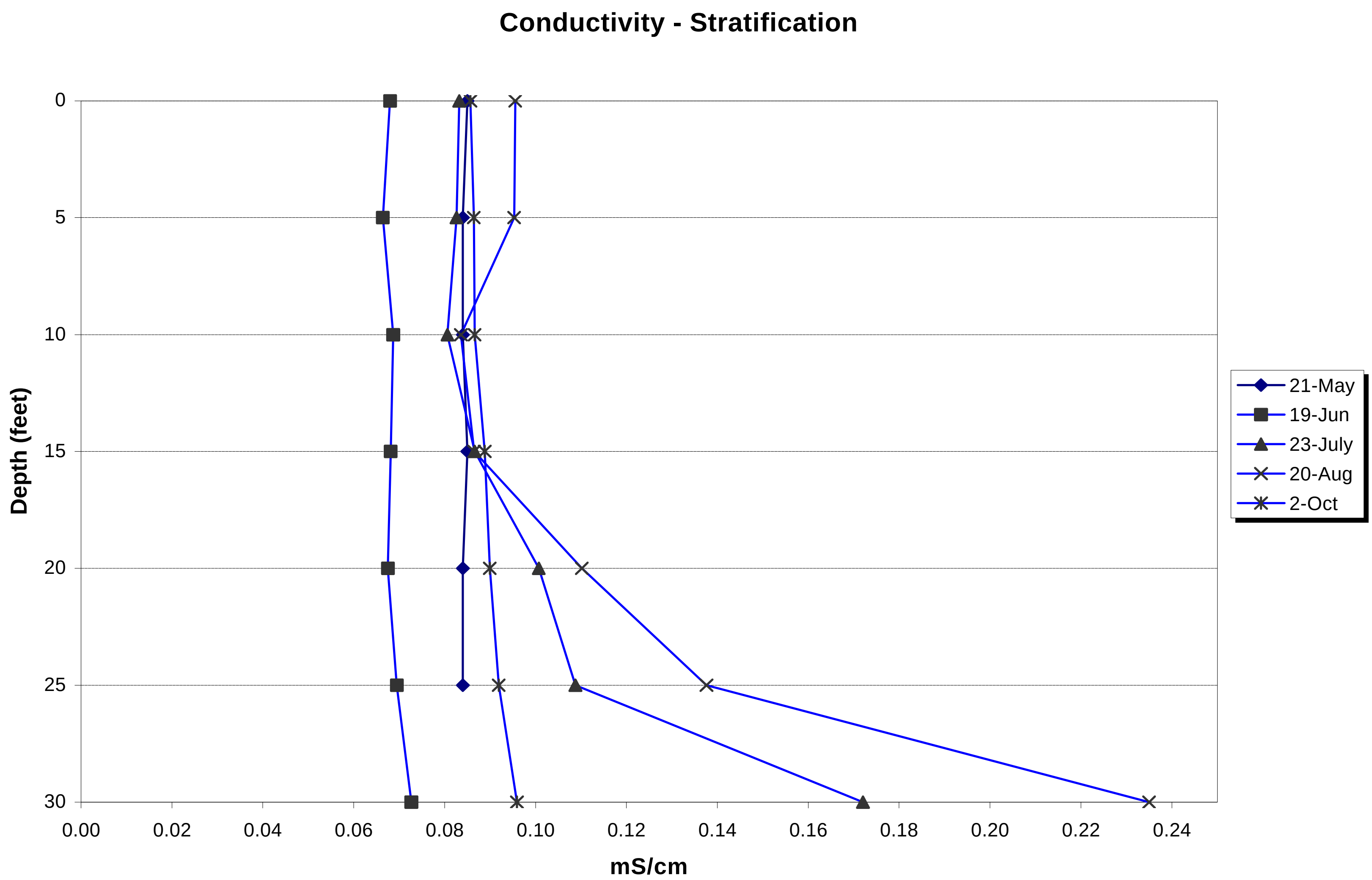

Figure 3-9. Conductivity stratification of Prompton Reservoir during 2002, from water quality measured at station PR-3. See Appendix A for a summary of plotted values.

Table 3-2. Summary of surface, middle, and bottom water quality monitoring data for Prompton Reservoir in 2002

STATION	DATE	NH3	NO2	NO3	PO4	TKN	TP	TDS	TSS	BOD5	ALK	DISS P	CHL_A
PR-1S	21-May	< 0.05	< 0.01	0.46	0.04	0.5	0.02	20	4	< 2	13	0.01	3.1
	19-Jun	0.11	< 0.01	< 0.05	0.11	0.4	0.02	56	7	< 2	16	0.03	2.56
	23-Jul	0.06	< 0.01	0.1	0.05	1.2	0.02	51	1	< 2	24	0.02	1.3
	20-Aug	0.16	< 0.01	0.07	0.06	1	0.02	59	1	< 2	26	0.02	2.17
	02-Oct	0.14	< 0.01	0.42	0.06	0.6	0.03	52	10	< 2	24	0.02	4.14
Mean		0.10	0.010	0.22	0.06	0.74	0.02	48	4.6	2.0	20.6	0.0	2.7
Maximum		0.16	0.010	0.46	0.11	1.20	0.03	59	10.0	2.0	26.0	0.0	4.1
Minimum		0.05	0.010	0.05	0.04	0.40	0.02	20	1.0	2.0	13.0	0.0	1.3
Std. Dev		0.05	0.000	0.20	0.03	0.34	0.00	16	3.9	0.0	5.7	0.0	1.1
No. of D		4.00	0.000	4.00	5.00	5.00	5.00	5	5.0	0.0	5.0	5.0	5.0
PR-2S	21-May	0.05	< 0.01	0.45	0.05	0.5	0.02	12	2	< 2	12	0.02	4.6
	19-Jun	0.1	< 0.01	< 0.05	0.1	1.4	0.01	47	2	2	18	0.03	10.45
	23-Jul	0.06	0.25	< 0.05	0.08	2.3	0.03	40	5	3	22	0.03	3.85
	20-Aug	0.08	< 0.01	< 0.05	0.14	1.9	0.07	44	12	3	22	0.05	6.86
	02-Oct	0.16	< 0.01	< 0.05	0.77	1.8	0.37	60	51	12	60	0.25	13.98
Mean		0.09	0.058	0.13	0.23	1.58	0.10	41	14.4	4.4	26.8	0.1	7.9
Maximum		0.16	0.250	0.45	0.77	2.30	0.37	60	51.0	12.0	60.0	0.3	14.0
Minimum		0.05	0.010	0.05	0.05	0.50	0.01	12	2.0	2.0	12.0	0.0	3.9
Std. Dev		0.04	0.107	0.18	0.30	0.68	0.15	18	20.9	4.3	19.0	0.1	4.2
No. of D		5.00	1.000	1.00	5.00	5.00	5.00	5	5.0	4.0	5.0	5.0	5.0
PR-2M	21-May	< 0.05	< 0.01	0.44	0.07	0.6	0.03	28	6	< 2	12	0.02	5.7
	19-Jun	0.15	< 0.01	< 0.05	0.1	0.6	0.03	46	3	< 2	16	0.03	7.71
	23-Jul	0.06	0.3	< 0.05	0.07	1.7	0.02	37	1	2	20	0.02	4.33
	20-Aug	0.1	< 0.01	< 0.05	0.12	1.3	0.05	48	14	4	24	0.04	5.87
	02-Oct	0.15	< 0.01	0.32	0.06	0.6	0.03	50	10	< 2	28	0.02	3.74
Mean		0.10	0.068	0.18	0.08	0.96	0.03	42	6.8	2.4	20.0	0.0	5.5
Maximum		0.15	0.300	0.44	0.12	1.70	0.05	50	14.0	4.0	28.0	0.0	7.7
Minimum		0.05	0.010	0.05	0.06	0.60	0.02	28	1.0	2.0	12.0	0.0	3.7
Std. Dev		0.05	0.130	0.19	0.03	0.51	0.01	9	5.3	0.9	6.3	0.0	1.5
No. of D		4.00	1.000	2.00	5.00	5.00	5.00	5	5.0	2.0	5.0	5.0	5.0
PR-2B	21-May	< 0.05	< 0.01	0.44	0.09	0.7	0.04	14	4	< 2	12	0.03	4.5
	19-Jun	0.17	< 0.01	< 0.05	0.1	0.7	0.04	54	2	< 2	14	0.03	4.37
	23-Jul	0.13	< 0.01	< 0.05	0.2	1.8	0.07	45	4	< 2	24	0.07	1.61
	20-Aug	0.25	< 0.01	< 0.05	0.22	1.3	0.08	64	11	3	24	0.07	3.89
	02-Oct	0.15	< 0.01	0.34	0.12	0.6	0.08	45	37	2	24	0.04	3.41
Mean		0.15	0.010	0.19	0.15	1.02	0.06	44	11.6	2.2	19.6	0.0	3.6
Maximum		0.25	0.010	0.44	0.22	1.80	0.08	64	37.0	3.0	24.0	0.1	4.5
Minimum		0.05	0.010	0.05	0.09	0.60	0.04	14	2.0	2.0	12.0	0.0	1.6
Std. Dev		0.07	0.000	0.19	0.06	0.52	0.02	19	14.6	0.4	6.1	0.0	1.2
No. of D		4.00	0.000	2.00	5.00	5.00	5.00	5	5.0	2.0	5.0	5.0	5.0

Table 3-2. (Continued)

STATION	DATE	NH3	NO2	NO3	PO4	TKN	TP	TDS	TSS	BOD5	ALK	DISS P	CHL_A
PR-3S	21-May	< 0.05	< 0.01	0.51	0.1	0.6	0.03	12	5	< 2	12	0.03	6
	19-Jun	0.13	< 0.01	< 0.05	0.09	0.7	0.04	52	7	3	30	0.03	9.66
	23-Jul	0.1	0.33	< 0.05	0.08	1.9	0.07	44	4	2	16	0.03	2.8
	20-Aug	< 0.05	< 0.01	< 0.05	0.19	2.3	0.1	50	8	4	22	0.06	5.97
	02-Oct	0.14	< 0.01	< 0.05	0.05	0.7	0.11	46	12	2	26	0.02	5.34
Mean		0.09	0.074	0.14	0.10	1.24	0.07	41	7.2	2.6	21.2	0.0	6.0
Maximum		0.14	0.330	0.51	0.19	2.30	0.11	52	12.0	4.0	30.0	0.1	9.7
Minimum		0.05	0.010	0.05	0.05	0.60	0.03	12	4.0	2.0	12.0	0.0	2.8
Std. Dev		0.04	0.143	0.21	0.05	0.80	0.04	16	3.1	0.9	7.3	0.0	2.5
No. of D		3.00	1.000	1.00	5.00	5.00	5.00	5	5.0	4.0	5.0	5.0	5.0
PR-3M	21-May	< 0.05	< 0.01	0.5	0.08	1.1	0.03	38	7	< 2	12	0.03	5.7
	19-Jun	0.14	< 0.01	< 0.05	0.09	0.8	0.04	53	3	< 2	18	0.03	7.33
	23-Jul	0.11	0.28	< 0.05	0.07	1.8	0.02	35	< 1	< 2	20	0.02	0.96
	20-Aug	0.12	< 0.01	< 0.05	0.08	1.3	0.03	37	< 1	< 2	22	0.02	3.95
	02-Oct	0.15	< 0.01	0.39	0.07	0.7	0.06	56	10	< 2	22	0.02	3.29
Mean		0.11	0.064	0.21	0.08	1.14	0.04	44	4.4	2.0	18.8	0.0	4.2
Maximum		0.15	0.280	0.50	0.09	1.80	0.06	56	10.0	2.0	22.0	0.0	7.3
Minimum		0.05	0.010	0.05	0.07	0.70	0.02	35	1.0	2.0	12.0	0.0	1.0
Std. Dev		0.04	0.121	0.22	0.01	0.44	0.02	10	4.0	0.0	4.1	0.0	2.4
No. of D		4.00	1.000	2.00	5.00	5.00	5.00	5	3.0	0.0	5.0	5.0	5.0
PR-3B	21-May	< 0.05	< 0.01	0.45	0.07	0.6	0.03	14	10	< 2	12	0.02	4.5
	19-Jun	0.35	< 0.01	< 0.05	0.08	0.8	0.03	50	6	< 2	18	0.03	2.58
	23-Jul	1.07	< 0.01	< 0.05	0.61	3.1	0.2	64	3	< 2	30	0.2	1.43
	20-Aug	3.28	< 0.01	< 0.05	1.26	4	0.45	62	3	3	38	0.41	2.19
	02-Oct	0.21	< 0.01	0.39	0.12	1	0.04	50	15	< 2	22	0.04	4.29
Mean		0.99	0.010	0.20	0.43	1.90	0.15	48	7.4	2.2	24.0	0.1	3.0
Maximum		3.28	0.010	0.45	1.26	4.00	0.45	64	15.0	3.0	38.0	0.4	4.5
Minimum		0.05	0.010	0.05	0.07	0.60	0.03	14	3.0	2.0	12.0	0.0	1.4
Std. Dev		1.34	0.000	0.20	0.52	1.55	0.18	20	5.1	0.4	10.2	0.2	1.3
No. of D		4.00	0.000	2.00	5.00	5.00	5.00	5	5.0	1.0	5.0	5.0	5.0
PR-4S	21-May	< 0.05	< 0.01	0.42	0.05	0.8	0.03	< 10	2	< 2	10	0.02	7.4
	19-Jun	0.11	< 0.01	< 0.05	0.08	0.7	0.03	47	8	< 2	16	0.02	8.82
	23-Jul	0.17	0.35	0.09	0.08	1.7	0.03	40	4	< 2	24	0.03	1.3
	20-Aug	0.18	< 0.01	0.17	0.09	1.2	0.03	42	2	2	24	0.03	3.39
	02-Oct	0.16	< 0.01	0.38	0.05	0.7	0.04	54	10	< 2	22	0.02	3.2
Mean		0.13	0.078	0.22	0.07	1.02	0.03	39	5.2	2.0	19.2	0.0	4.8
Maximum		0.18	0.350	0.42	0.09	1.70	0.04	54	10.0	2.0	24.0	0.0	8.8
Minimum		0.05	0.010	0.05	0.05	0.70	0.03	10	2.0	2.0	10.0	0.0	1.3
Std. Dev		0.05	0.152	0.17	0.02	0.43	0.00	17	3.6	0.0	6.1	0.0	3.2
No. of D		4.00	1.000	4.00	5.00	5.00	5.00	4	5.0	1.0	5.0	5.0	5.0

3.2.1 Ammonia

Ammonia in the water column of Prompton Reservoir was generally low during 2002. With the exception of PR-3 in July and August, concentrations measured at most stations were near or less than the method detection limit (0.05-mg/L), averaging 0.12-mg/L throughout the monitoring period (Fig. 3-10). The highest concentrations of ammonia were measured in bottom waters of the deeper portion of the reservoir. Concentrations at station PR-3 during July and August averaged 2.2-mg/L. Increased ammonia is characteristic of low dissolved oxygen environments in stratified lakes resulting from the decomposition of organic materials. Among surface waters, ammonia was most commonly detected downstream of the reservoir, an effect likely due to deeper water releases by Prompton Reservoir dam. Concentrations measured at PR-4 ranged as high as 0.134-mg/L in August.

In 2002, Prompton Reservoir was for the most part in compliance with the PADEP water quality standard for ammonia, which is dependent on temperature and pH (Table 3-3). For all measures of ammonia, we calculated specific criteria based on the temperature and pH at the time of sampling. Overall, only two measures of ammonia may have exceeded corresponding criteria. The ammonia concentrations at the surface of stations PR-2 and PR-3 in August were 0.08-mg/L and less than the method detection limit of 0.05-mg/L, respectively. However, the ammonia criterion at a temperature of 30 C and a pH of 9.50 is 0.05-mg/L.

Table 3-3. PADEP ammonia nitrogen criteria (Pennsylvania Code, Title 25, Chapter 93, 2002). Specific ammonia criteria dependent on temperature and pH.

PH	10 °C	15 °C	20 °C	25 °C	30 °C
6.50	25.5	17.4	12.0	8.4	5.9
6.75	23.6	16.0	11.1	7.7	5.5
7.00	20.6	14.0	9.7	6.8	4.8
7.25	16.7	11.4	7.8	5.5	3.9
7.50	12.4	8.5	5.9	4.1	2.9
7.75	8.5	5.8	4.0	2.8	2.0
8.00	5.5	5.8	4.0	2.8	2.0
8.25	3.4	2.3	1.6	1.2	0.9
8.50	2.0	1.4	1.0	0.7	0.6
8.75	1.2	0.9	0.6	0.5	0.4
9.00	0.8	0.5	0.4	0.3	0.3
9.25	0.36	0.24	0.17	0.12	0.08
9.50	0.20	0.13	0.10	0.07	0.05

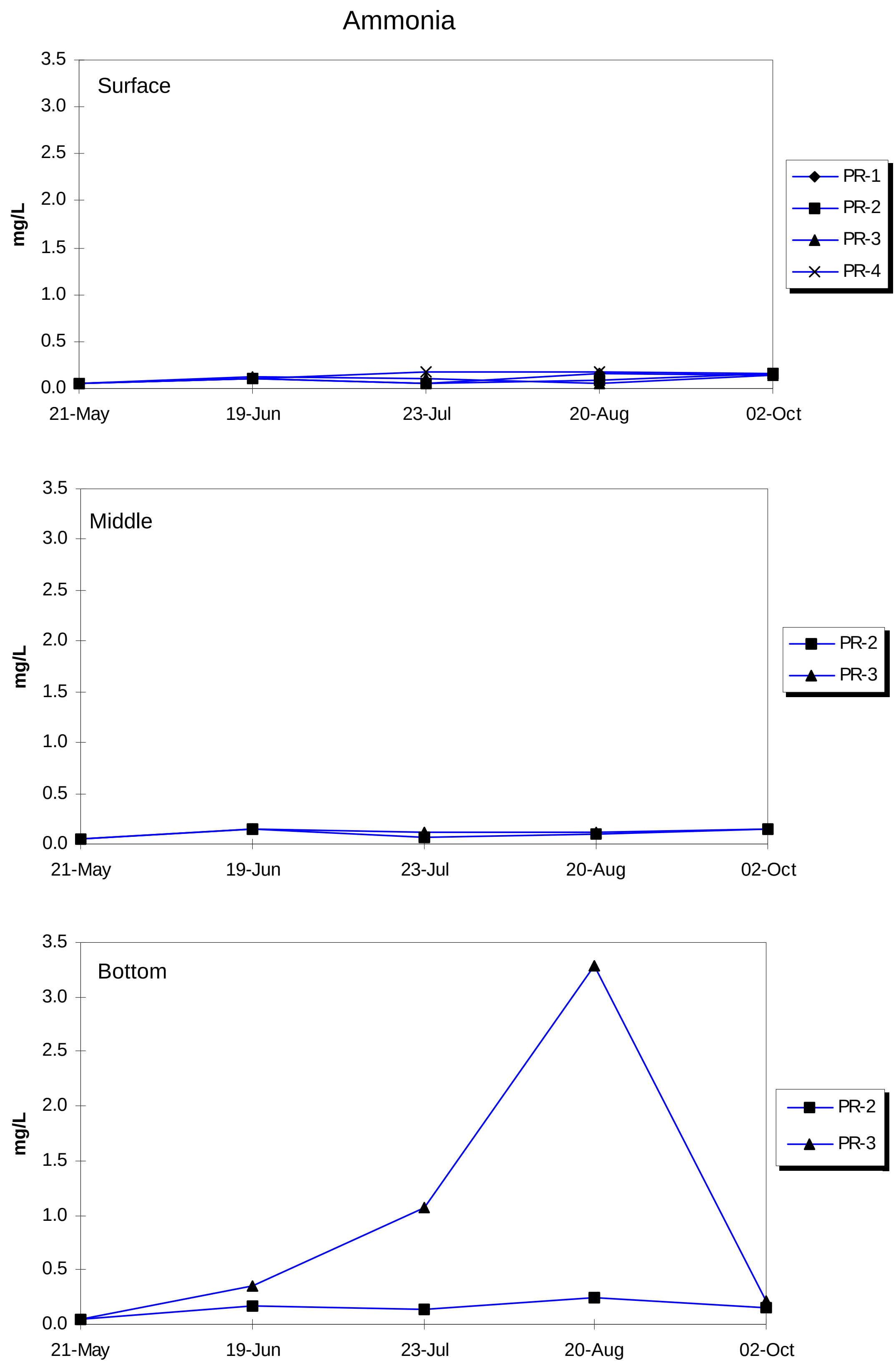

Figure 3-10. Ammonia measured in surface, middle, and bottom waters of Prompton Reservoir in 2002

A seasonal trend analysis of ammonia was conducted for individual stations of Prompton Reservoir, combining 2002 and historical data. The Mann-Kendall statistic was applied to station data collected over the past 25 years or more, separately for spring (April to June) and summer (July to October) seasons. Stations included in the analysis represented upstream sources (PR-1) and the main reservoir (PR-2). Additionally, the downstream station (PR-4) was evaluated this year using the previous seven years data.

Ammonia concentrations appear to have decreased throughout the reservoir drainage area during both seasons. Seasonal trends were significant during the spring and summer at stations PR-1 and PR-2 and during the spring at PR-3. The trends reflected yearly decreases ranging from 0.003 to 0.010 mg/L (Table 3-4). In general, summer rates of decrease were slightly higher than for spring. The widespread trends appear to be driven by higher concentrations detected in the late 1970s; most concentrations in subsequent years have been consistently lower.

Table 3-4. Seasonal trends of ammonia concentration at individual stations of Prompton Reservoir calculated with the Mann-Kendall Statistic. Shaded values are significant at P = 0.05.

Station	# of Years Spring/Summer	Spring		Summer	
		P Level	Rate(mg/L)	P Level	Rate (mg/L)
Surface Water					
PR-1	25	< 0.01	-0.0034	< 0.01	-0.0039
PR-2	24/25	< 0.01	-0.0041	< 0.01	-0.0065
PR-3	24/25	< 0.05	-0.0033	< 0.01	-0.0100
PR-4	7/8	NS	0.0043	NS	0.0166

3.2.2 Nitrite and Nitrate

Nitrite in the waters of Prompton Reservoir was consistently low during 2002. Concentrations measured at most stations and depths were near or less than the method detection limit (0.05-mg/L) throughout the monitoring period (Fig. 3-11). The only detections of nitrite occurred during July in the surface waters of PR-2, -3, and -4 as well as the middle waters of PR-3 and PR-4. The highest concentration of nitrite (0.35-mg/L) was measured downstream of the reservoir (station PR-2) during July.

Nitrate was also generally low in the water column of Prompton Reservoir in 2002. Concentrations at all stations and depths averaged 0.19-mg/L and ranged less than 0.5-mg/L throughout the monitoring period (Fig. 3-12). Nitrate measured upstream and downstream of the reservoir were most often greatest, averaging 0.22-mg/L; however, the peak value of 0.5-mg/L was observed in the reservoir at station PR-3 in May.

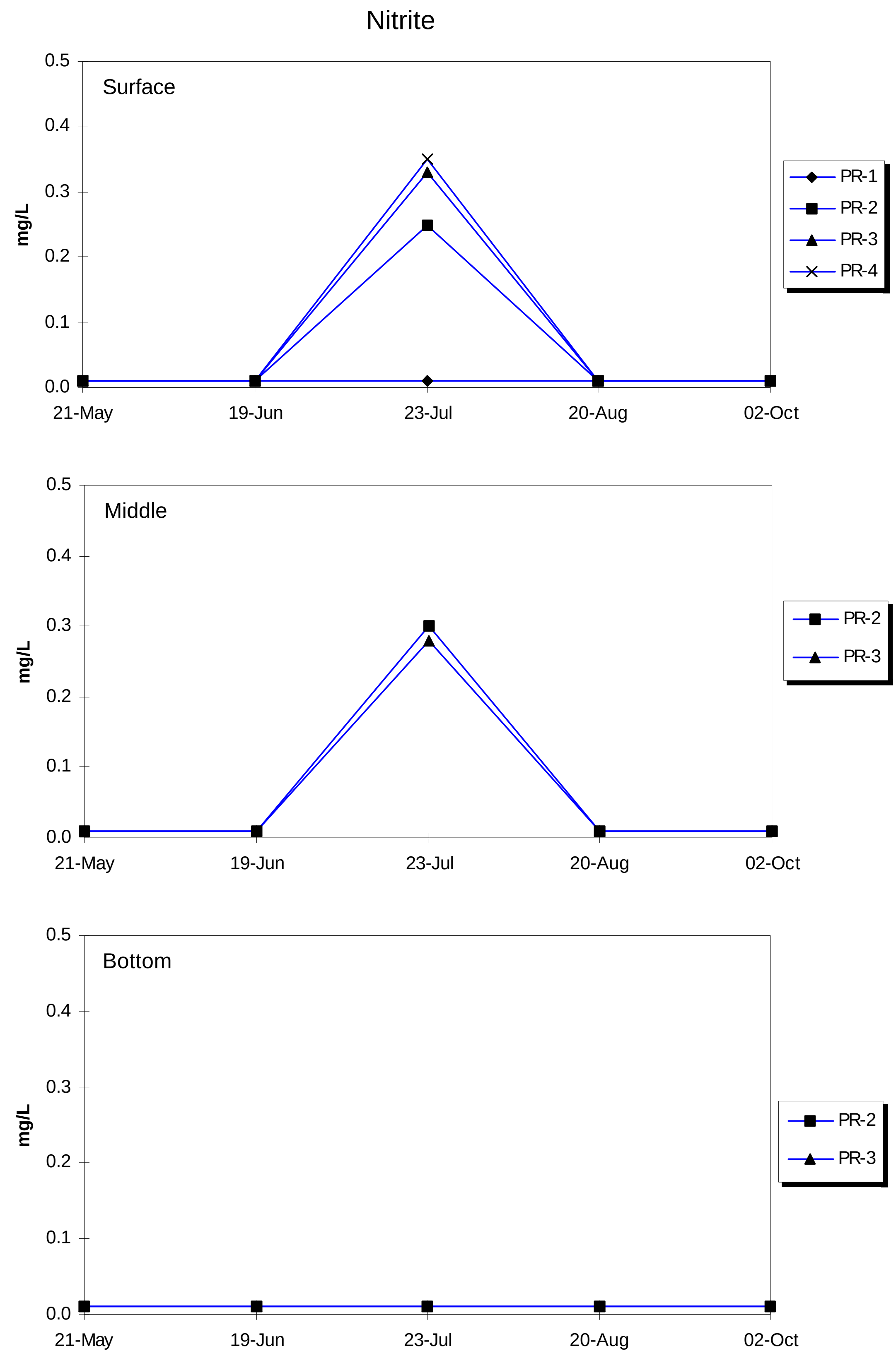

Figure 3-11. Nitrite measured in surface, middle, and bottom waters of Prompton Reservoir in 2002

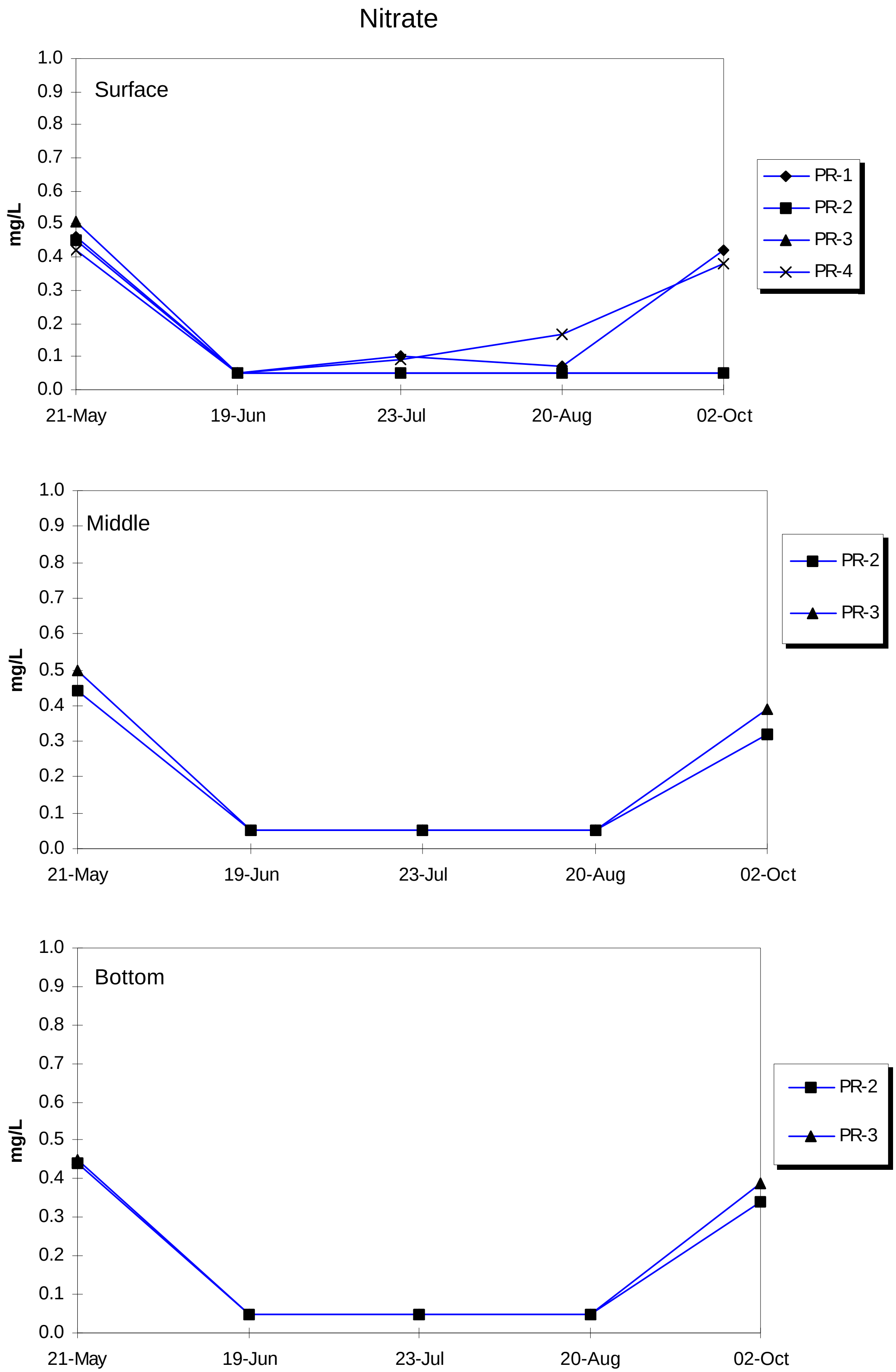

Figure 3-12. Nitrate measured in surface, middle, and bottom waters of Prompton Reservoir in 2002

Concentrations of nitrite and nitrate in the water column of Prompton Reservoir were in compliance with PADEP water quality standards in 2002. The PADEP standard for the nitrogen is less than 10 mg/L for the sum of both parameters (nitrite + nitrate).

3.2.3 Total Inorganic Nitrogen

Concentrations of ammonia, nitrite, and nitrate measured in 2002 and historical data collected from over the past 23 years were analyzed for seasonal trends. The trend analysis was conducted for spring and summer periods, separately for stations representative of the reservoir (PR-2) and downstream (PR-4) monitoring. Concentrations of total nitrogen have decreased in the reservoir and downstream during both seasons (Figs. 3-13 and 3-14). All of the regression lines were significant ($P < 0.05$) except downstream in the summer. The strongest trend ($R^2 = 0.375$) was determined for the reservoir during the summer, and reflected an average decrease over 10 years of 0.3 mg/L. Springtime trends were weaker ($R^2 < 0.27$ to 0.30), but corresponded to similar reductions in nitrogen concentrations.

A seasonal trend analysis of total nitrogen was also conducted for individual stations of Prompton Reservoir, combining 2002 and historical data. The Mann-Kendall statistic was applied to station data collected over the past 24 years or more, separately for spring (April to June) and summer (July to October) seasons. Stations included in the analysis represented upstream (PR-1), main reservoir (PR-2), and downstream (PR-4) sources. Total nitrogen appears to have decreased at stations PR-1, -2, and -3. Significant decreasing trends were determined at these stations for both spring and summer seasons (Table 3-5). Overall, yearly rates of decrease ranged from 0.01 to 0.02-mg/L. The reduction of total nitrogen in the waters of Prompton Reservoir can be considered an improvement in water quality.

Table 3-5. Seasonal trends of total nitrogen concentration at individual stations of Prompton Reservoir calculated with the Mann-Kendall Statistic. Shaded values are significant at $P = 0.05$.

Station	# of Years Spring/Summer	Spring		Summer	
		P Level	Rate(mg/L)	P Level	Rate (mg/L)
Surface Water					
PR-1	25/24	< 0.05	-0.0110	< 0.05	-0.0143
PR-2	24	< 0.001	-0.0219	< 0.01	-0.0153
PR-3	24	< 0.001	-0.0178	< 0.001	-0.0206
PR-4	7/7	NS	-0.0268	NS	0.0240

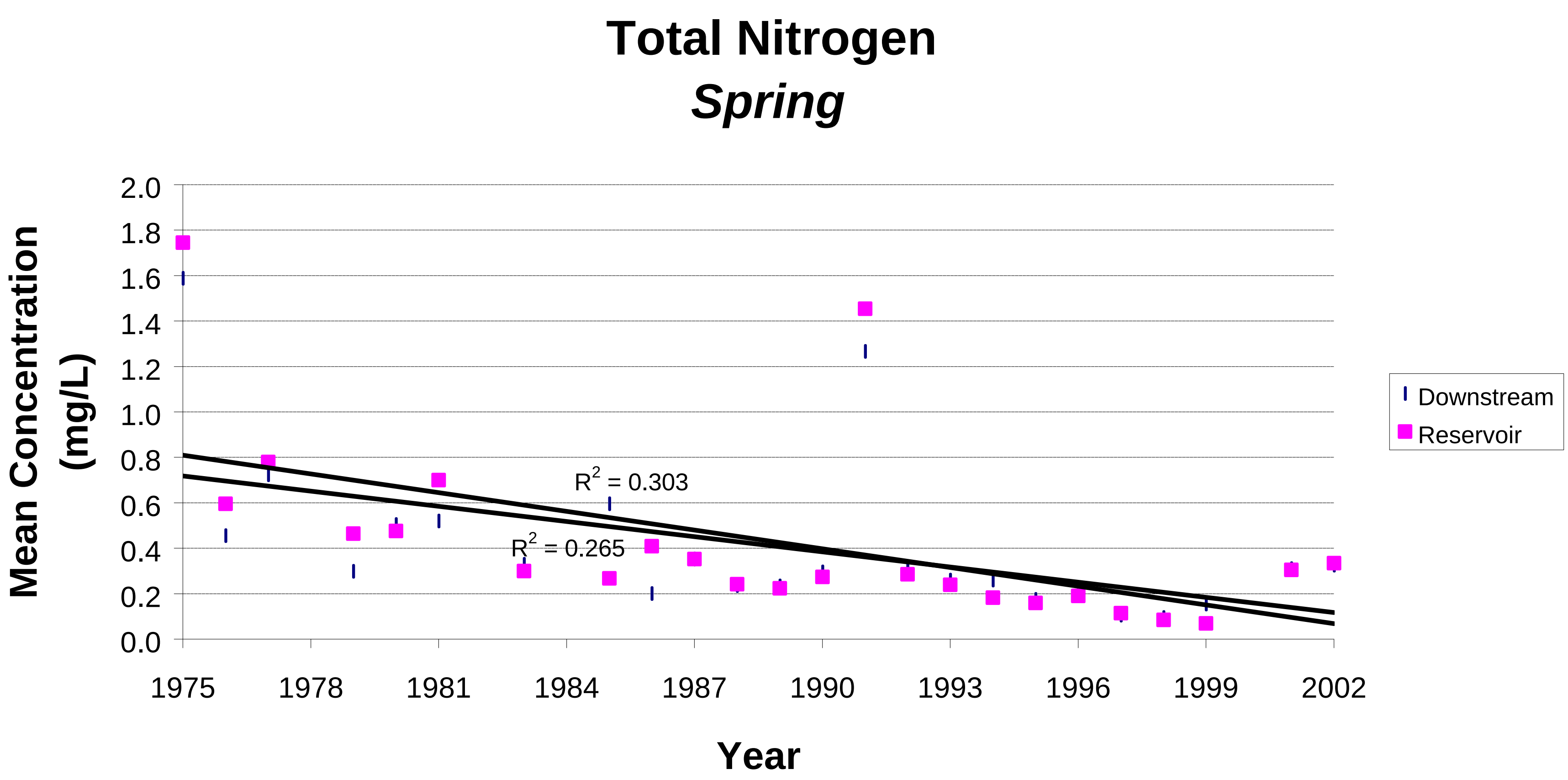

Figure 3-13. Seasonal trend analysis for total nitrogen in surface water during spring at Prompton Reservoir

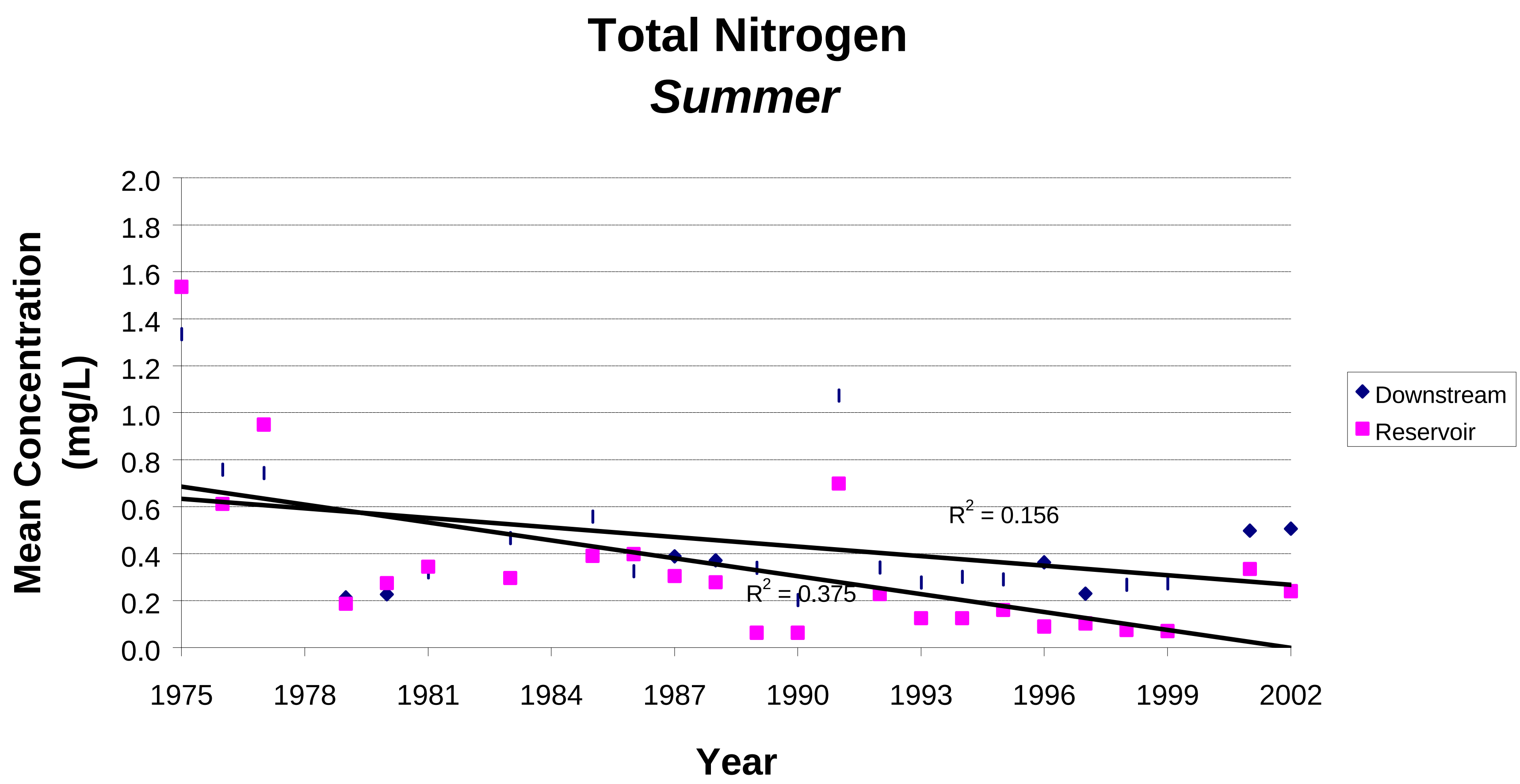

Figure 3-14. Seasonal trend analysis for total nitrogen in surface water during summer at Prompton Reservoir

3.2.4 Total Kjeldahl Nitrogen

Total Kjeldahl nitrogen (TKN) is a measure of organic nitrogen that also includes ammonia. TKN in the water column of Prompton Reservoir was generally low during 2002. TKN followed a general pattern of increasing from May to August in the bottom water and through July in the surface and middle waters. TKN decreased for all stations and depths in October. Concentrations at most stations and depths averaged 1.2-mg/L throughout the monitoring period and ranged to 4.0-mg/L in August (Fig. 3-15). Among bottom waters, TKN in the lower reservoir-body (station PR-3) averaged 1.2-mg/L throughout the monitoring period.

3.2.5 Dissolved Phosphate

Dissolved phosphate in the water column of Prompton Reservoir was consistently low during 2002. Concentrations measured at all stations and most depths average 0.15-mg/L throughout the monitoring period (Fig. 3-16). The highest concentration of dissolved phosphate (1.3-mg/L) was observed in the bottom waters of PR-3 in August.

3.2.6 Dissolved Phosphorus

Dissolved phosphorus in the water column of Prompton Reservoir was consistently low during 2002. Concentrations measured at all stations and most depths averaged 0.049-mg/L throughout the monitoring period (Fig. 3-17). The highest concentration of dissolved phosphate (0.41-mg/L) was observed in the bottom waters of PR-3 in August.

3.2.7 Total Phosphorus

Total phosphorus in the water column of Prompton Reservoir was consistently low during 2002. With one exception, concentrations at most stations and depths averaged 0.053-mg/L (Fig. 3-18). The highest concentration of total phosphorus (0.45-mg/L) was in the reservoir at the bottom of PR-3 in August. Slightly elevated concentrations were measured in the lower column of the reservoir primarily during the late summer. Concentrations of total phosphorus in bottom waters of stations PR-2 and PR-3 averaged 0.15-mg/L and ranged to 0.45 mg/L from July through October (Fig. 3-18). Higher concentrations of phosphorus in the lower water column are characteristic of temperature-stratified lakes. Low DO conditions create a reducing chemical environment that can mobilize phosphorus from bottom sediment.

Total phosphorus concentrations measured in 2002 and historical data collected from over the past 22 years were analyzed for seasonal trends. The trend analysis was conducted for spring and summer periods, separately for stations representative of the

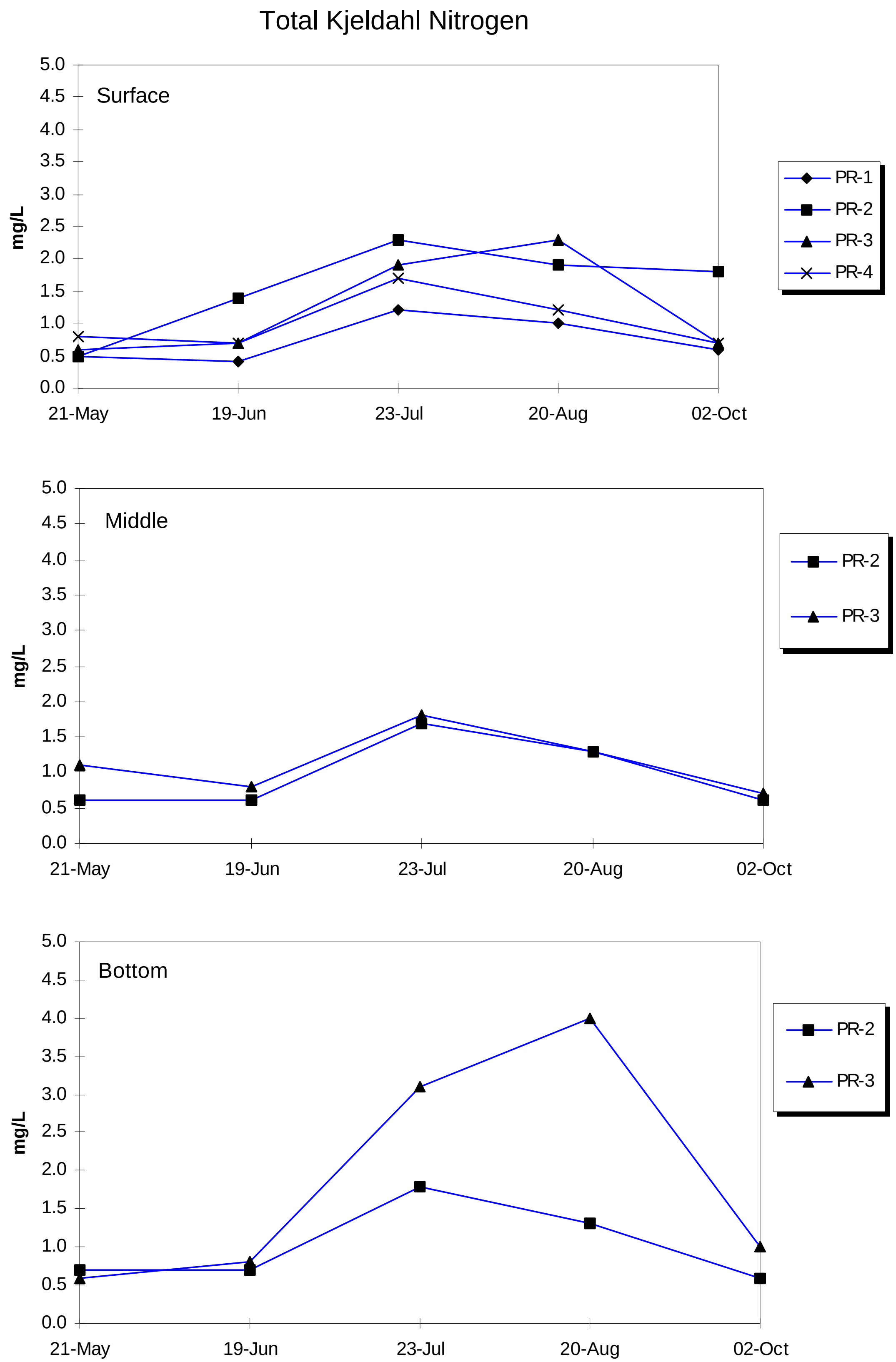

Figure 3-15. Total Kjeldahl nitrogen measured in surface, middle, and bottom waters of Prompton Reservoir in 2002

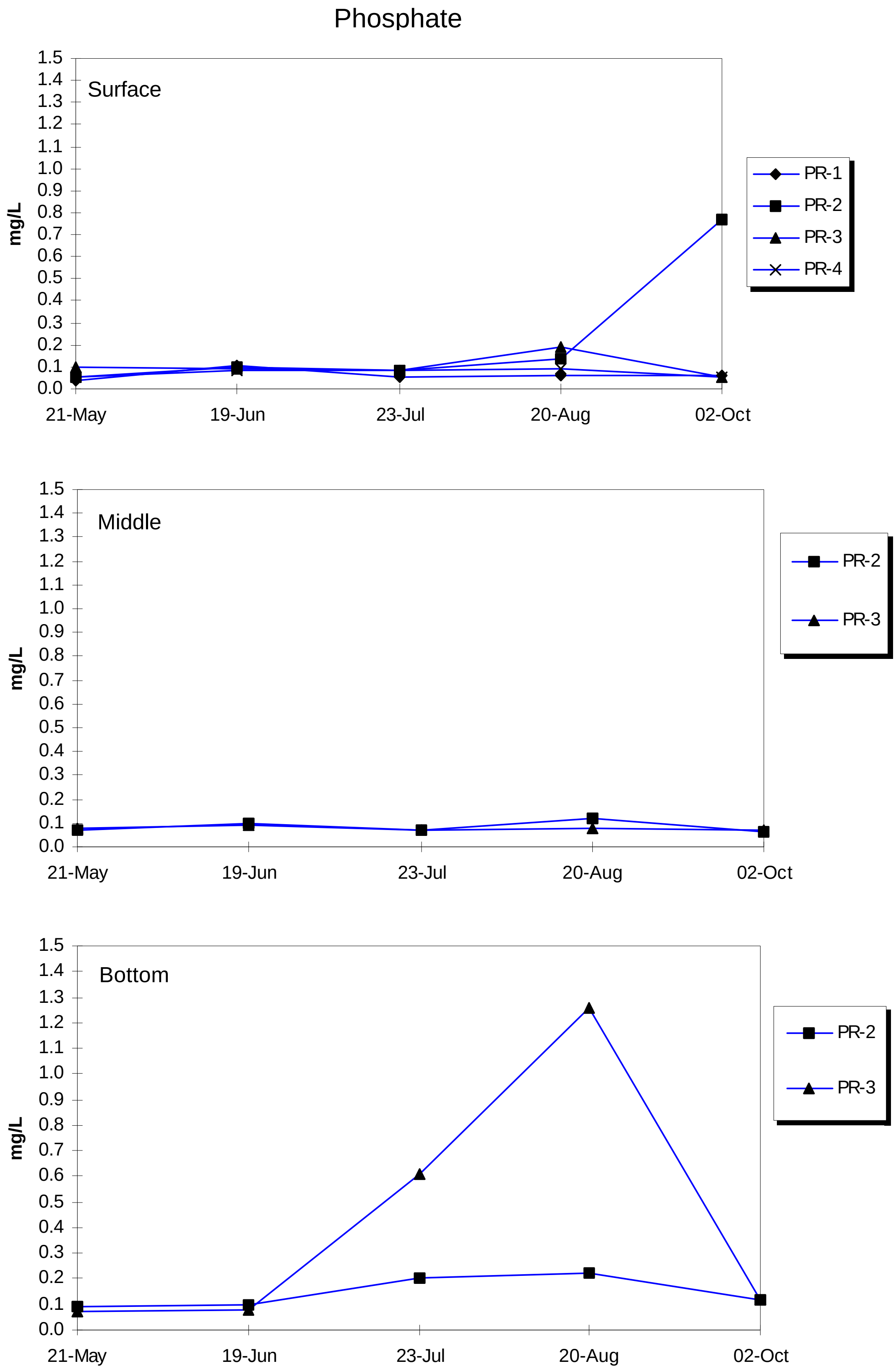

Figure 3-16. Dissolved phosphate measured in surface, middle, and bottom waters of Prompton Reservoir in 2002

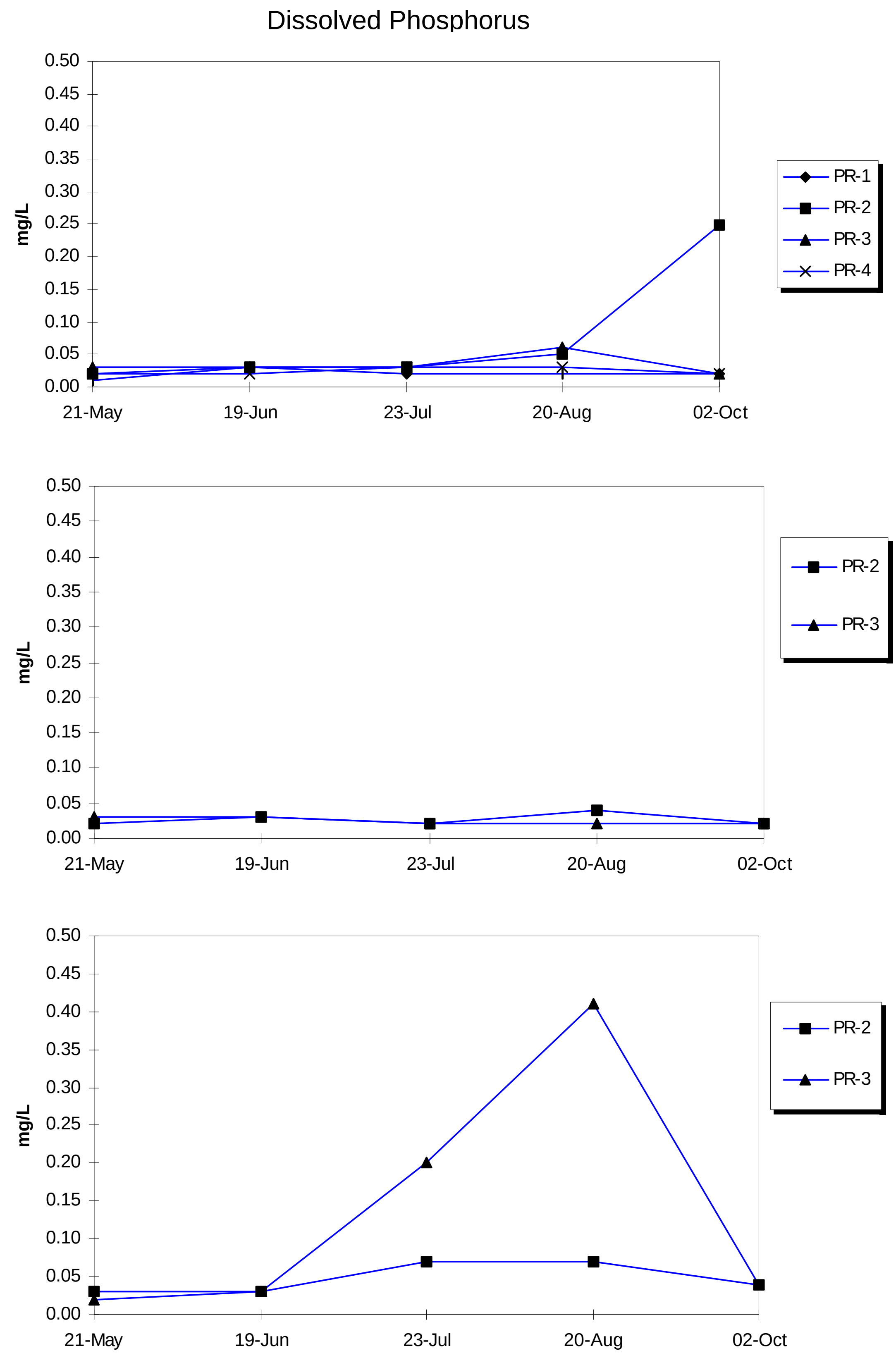

Figure 3-17. Dissolved phosphorous measured in surface, middle, and bottom waters of Prompton Reservoir in 2002

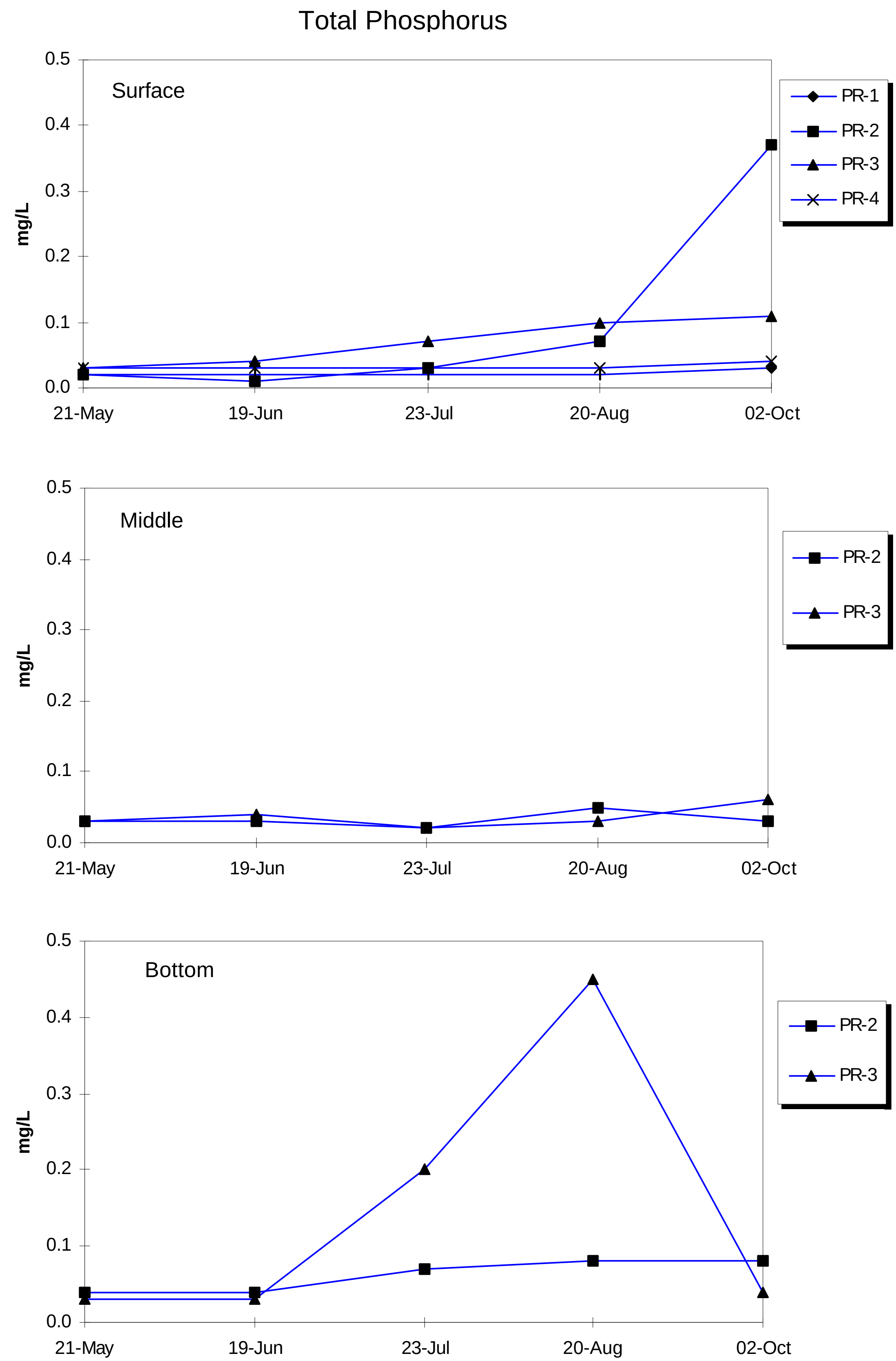

Figure 3-18. Total phosphorus measured in surface, middle, and bottom waters of Prompton Reservoir in 2002

reservoir (PR-2) and downstream (PR-4) monitoring. Total phosphorus did not change consistently over the past two decades. None of the seasonal trends were significant for either location ($P < 0.05$; Figs. 3-19 and 3-20).

A seasonal trend analysis of total phosphorus was also conducted for individual stations of Prompton Reservoir, combining 2002 and historical data. The Mann-Kendall statistic was applied to station data collected over the past 21 years, separately for spring (April to June) and summer (July to October) seasons. Stations included in the analysis represented upstream sources (PR-1) and the main reservoir (PR-2 and PR-3) and the downstream station (PR-4).

Total phosphorus in the surface waters of Prompton Reservoir has not significantly changed over the past two decades. None of the seasonal trends were significant for any of the stations (Table 3-6). Because total phosphorus is usually the limiting nutrient for plant growth in freshwater environments, the absence of a significant trend is not unlikely. Algae or other plants would most likely take up additional phosphorus entering into the surface water environment.

Table 3-6. Seasonal trends of total phosphorus concentration at individual stations of Prompton Reservoir calculated with the Mann-Kendall Statistic.

Station	# of Years Spring/Summer	Spring		Summer	
		P Level	Rate(mg/L)	P Level	Rate (mg/L)
Surface Water					
PR-1	20/21	NS	-0.0001	NS	-0.0002
PR-2	20/21	NS	-0.0005	NS	-0.0013
PR-3	20/21	NS	-0.0005	NS	0.0011
PR-4	7/8	NS	-0.0029	NS	-0.0022

3.2.8 Total Dissolved Solids

Total dissolved solids (TDS) in the water column of Prompton Reservoir were consistently low during 2002. Concentrations measured at all stations and most depths average 43-mg/L and ranged from 64 to less than the detection limit of 10-mg/L throughout the monitoring period (Fig. 3-21).

TDS concentrations measured in 2002 and historical data collected from the past 25 years were analyzed for seasonal trends (Figs. 3-22 and 3-23). Trend analysis was conducted for spring and summer periods, separately for stations representative of the reservoir (PR-2) and downstream (PR-4) monitoring. TDS decreased downstream of the reservoir during the summer. The downstream trend was significant ($R^2 = 0.29$; $P < 0.006$)

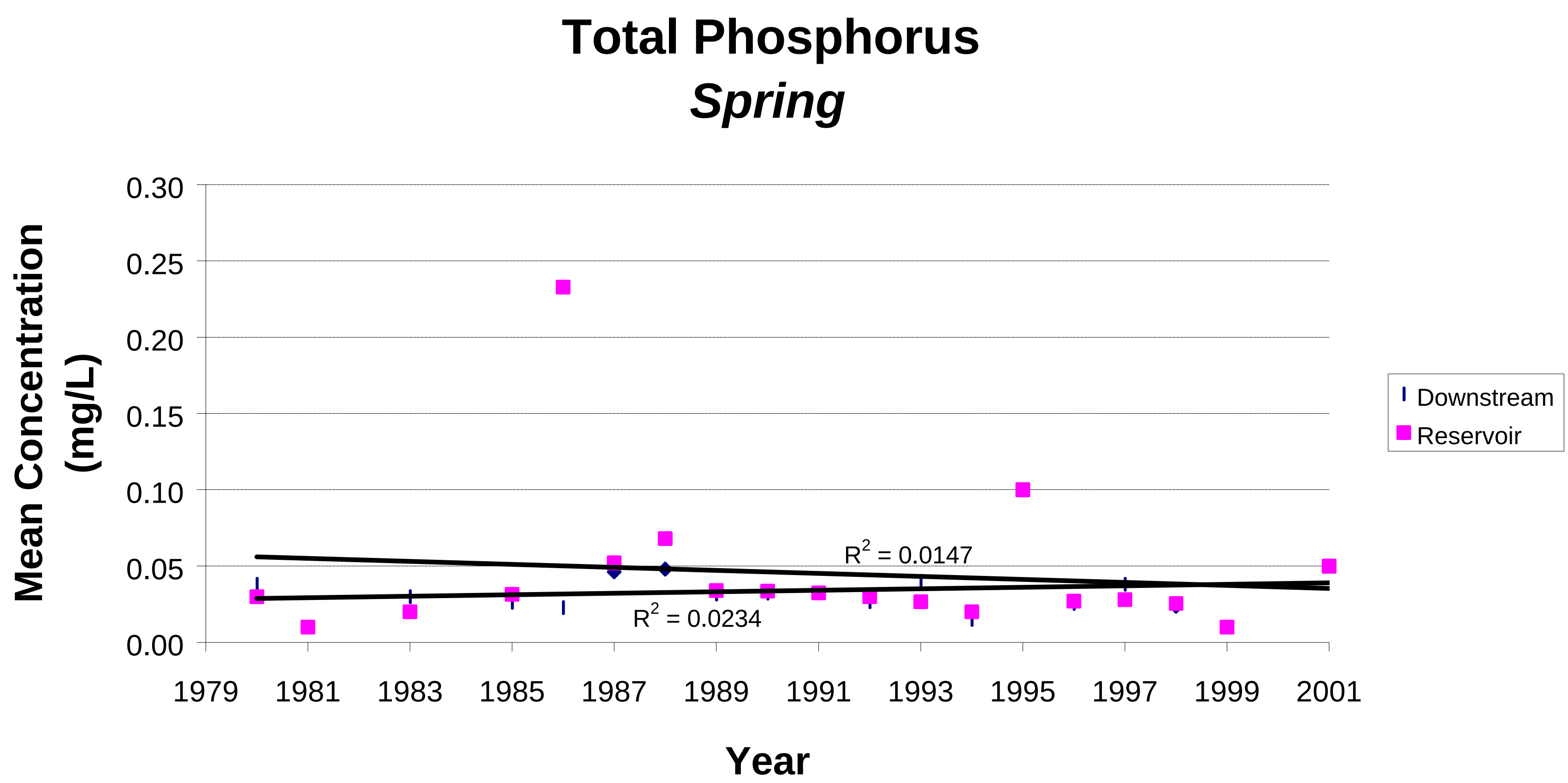

Figure 3-19. Seasonal trend analysis for total phosphorus in surface water during spring at Prompton Reservoir

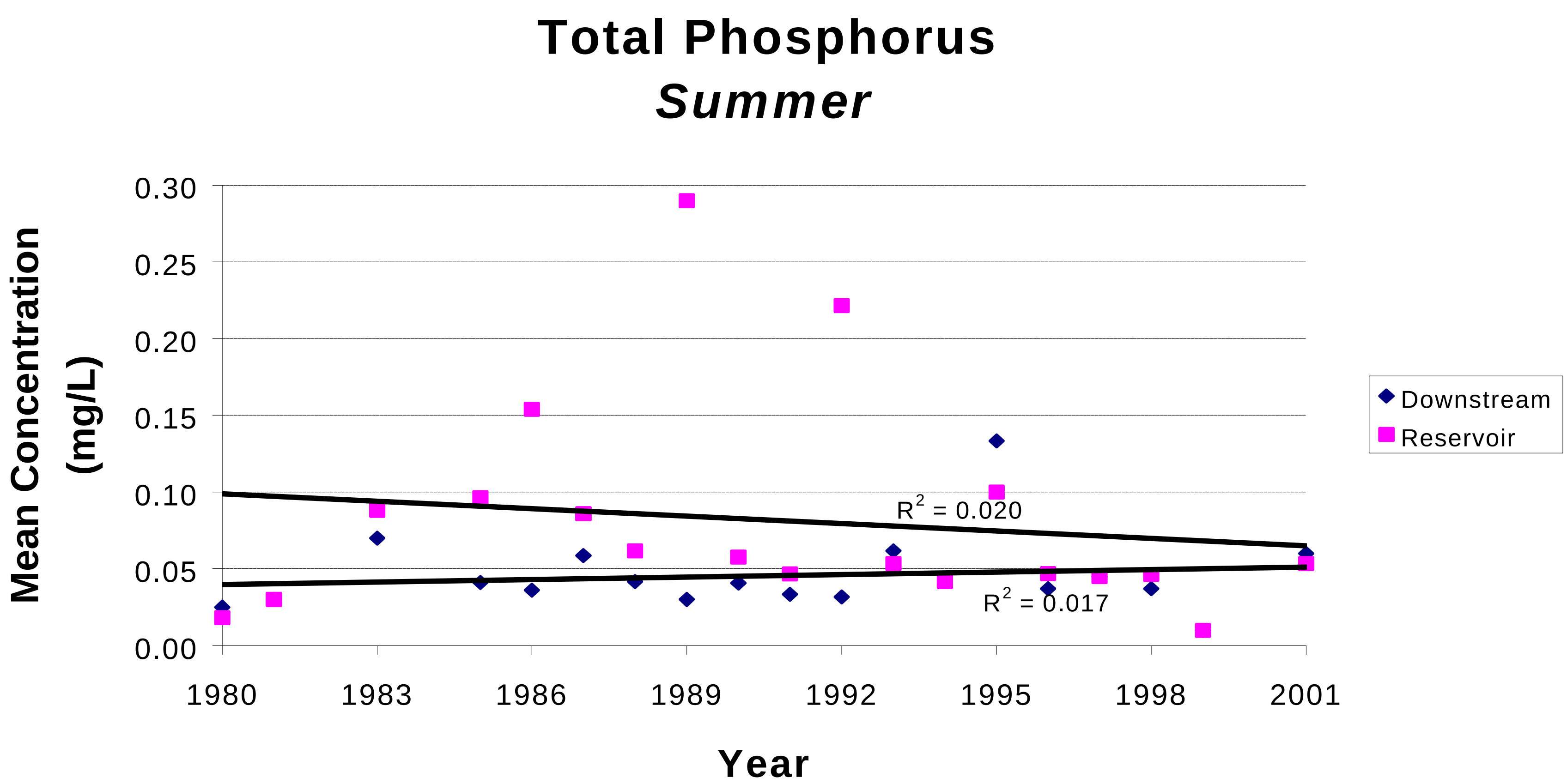

Figure 3-20. Seasonal trend analysis for total phosphorus in surface water during summer at Prompton Reservoir

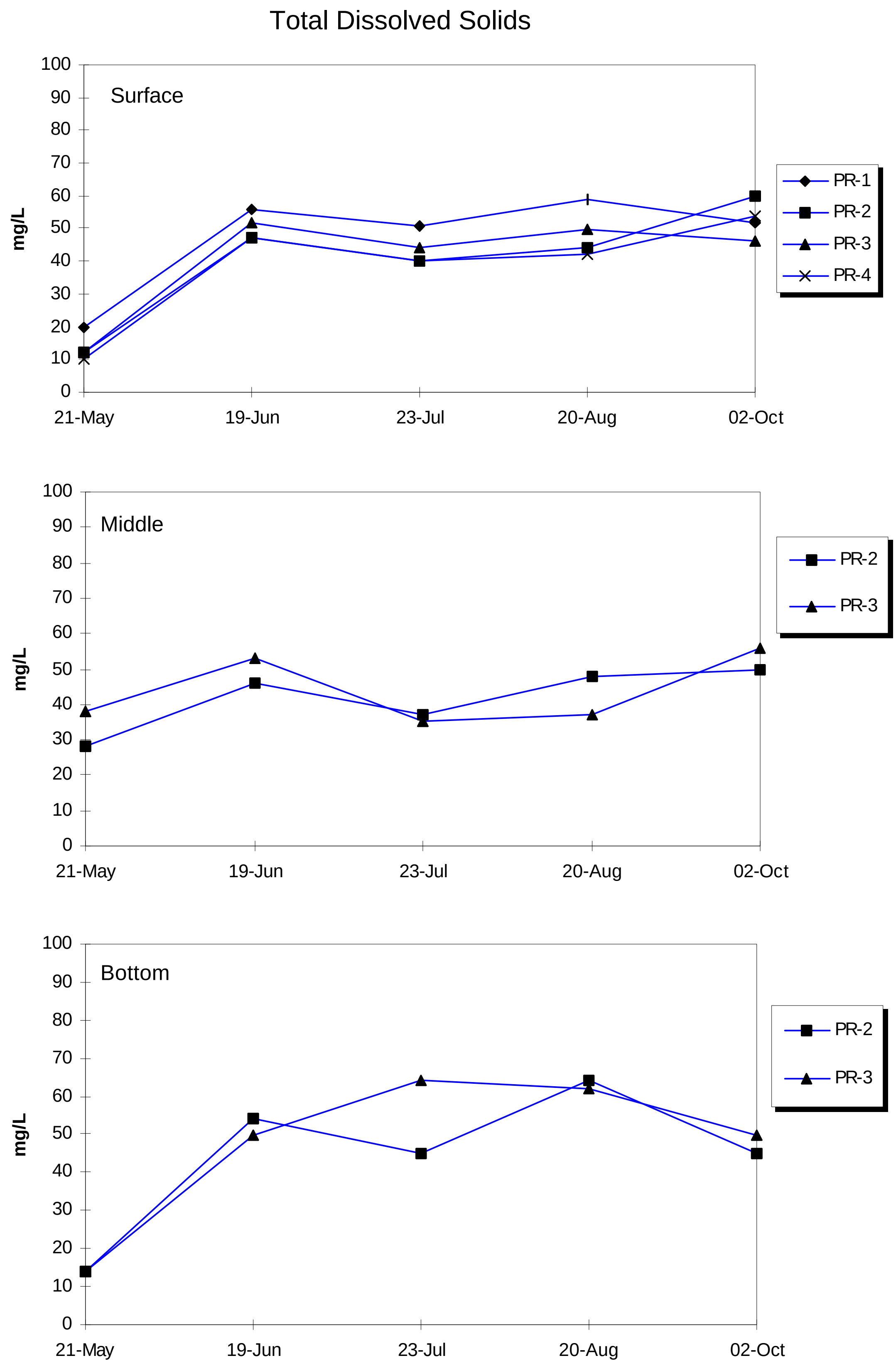

Figure 3-21. Total dissolved solids in surface, middle, and bottom waters of Prompton Reservoir in 2002. The PADEP water quality standard for TDS is a maximum concentration of 500 mg/L.

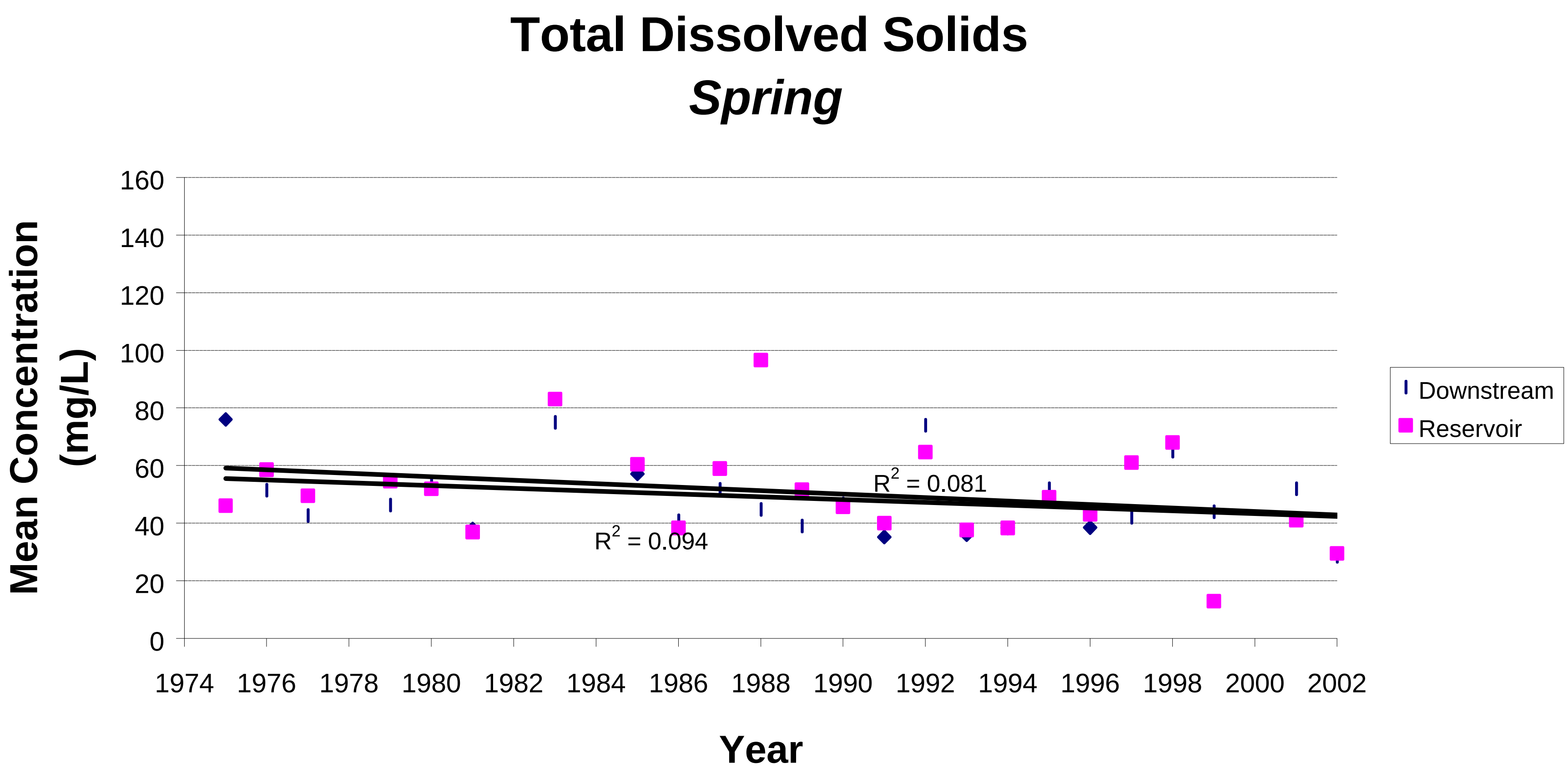

Figure 3-22. Seasonal trend analysis for total dissolved solids in surface water during spring at Prompton Reservoir

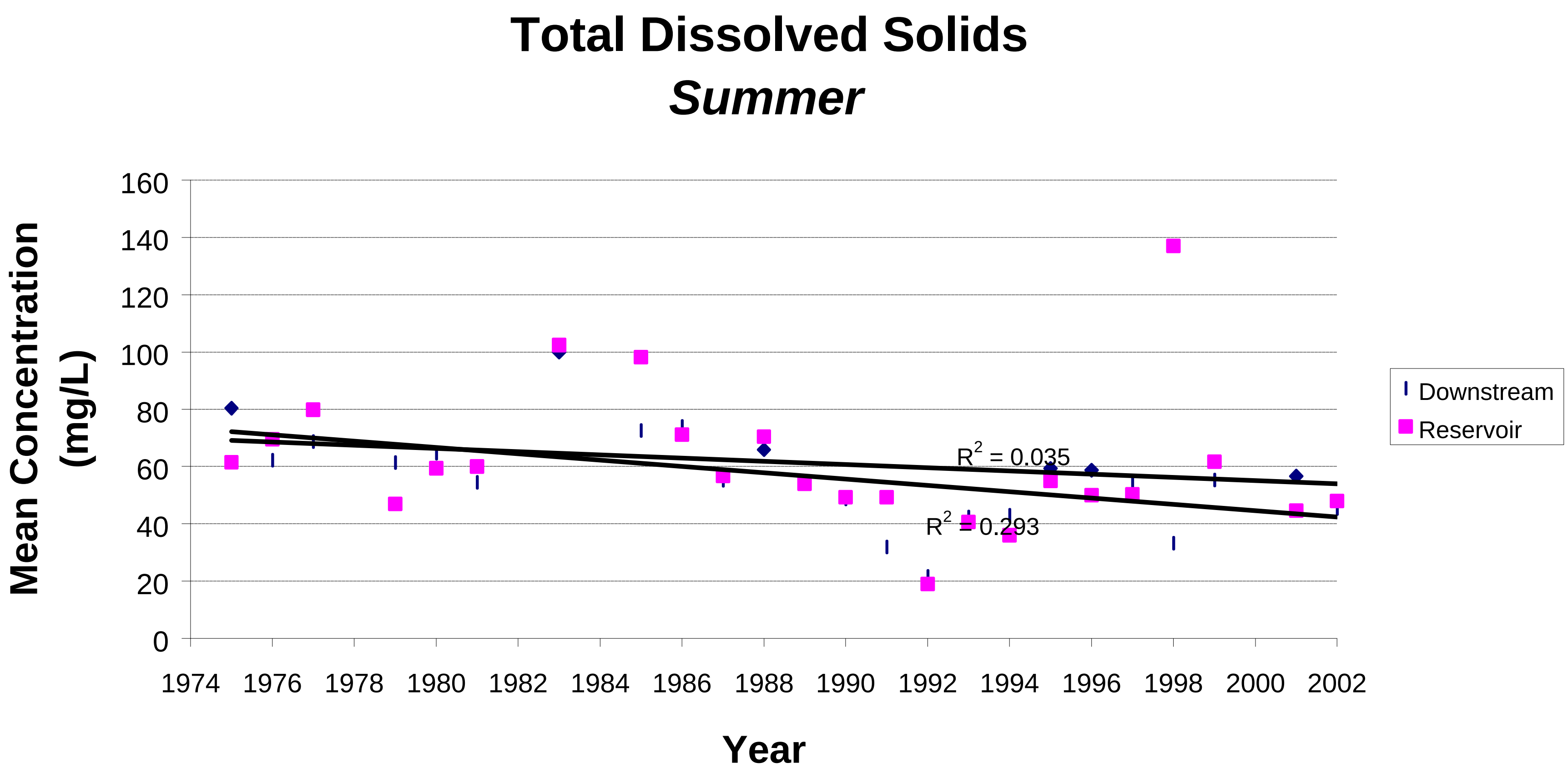

Figure 3-23. Seasonal trend analysis for total dissolved solids in surface water during summer at Prompton Reservoir

and reflected an average yearly decrease of approximately 1-mg/L (Fig. 3-23). No significant trends of TDS were determined for either location in the spring season or for the reservoir in the summer season.

A seasonal trend analysis of TDS was also conducted for individual stations of Prompton Reservoir, combining 2002 and historical data. The Mann-Kendall statistic was applied to station data collected over the past 25 years or more, separately for spring (April to June) and summer (July to October) seasons. Stations included in the analysis represented upstream sources (PR-1) and the main reservoir (PR-2 and PR-3). Additionally, the downstream station (PR-4) was added this year using the previous eight years data.

TDS decreased at stations PR-1, -2, and -3 during the summer season as well as the spring season for PR-3. The summer trend for these stations was significant ($P < 0.05$) and reflected an average annual decrease of 0.78-mg/L (Table 3-7).

Table 3-7. Seasonal trends of total dissolved solids concentration at individual stations of Prompton Reservoir calculated with the Mann-Kendall Statistic. Shaded values are significant at $P = 0.05$.

Station	**# of Years Spring/Summer**	**Spring**		**Summer**	
		P Level	**Rate(mg/L)**	**P Level**	**Rate (mg/L)**
Surface Water					
PR-1	25	NS	-0.5159	< 0.05	-0.5663
PR-2	24/25	NS	-0.5594	< 0.05	-0.8428
PR-3	24/25	< 0.05	-0.6762	< 0.001	-1.0179
PR-4	7/8	NS	-2.0000	NS	-1.4556

3.2.9 Total Suspended Solids

Total suspended solids (TSS) were for the most part low in the water column of Prompton Reservoir during 2002; however, slightly higher concentrations were present in the lower water column during the summer. Concentrations at most stations and depths averaged 7.78-mg/L and ranged between the minimum method detection limit of 1-mg/L to 51-mg/L (Fig. 3-24). During July, August, and September in the lower water column of stations PR-2 and PR-3 the concentrations of TSS averaged 9.2-mg/L.

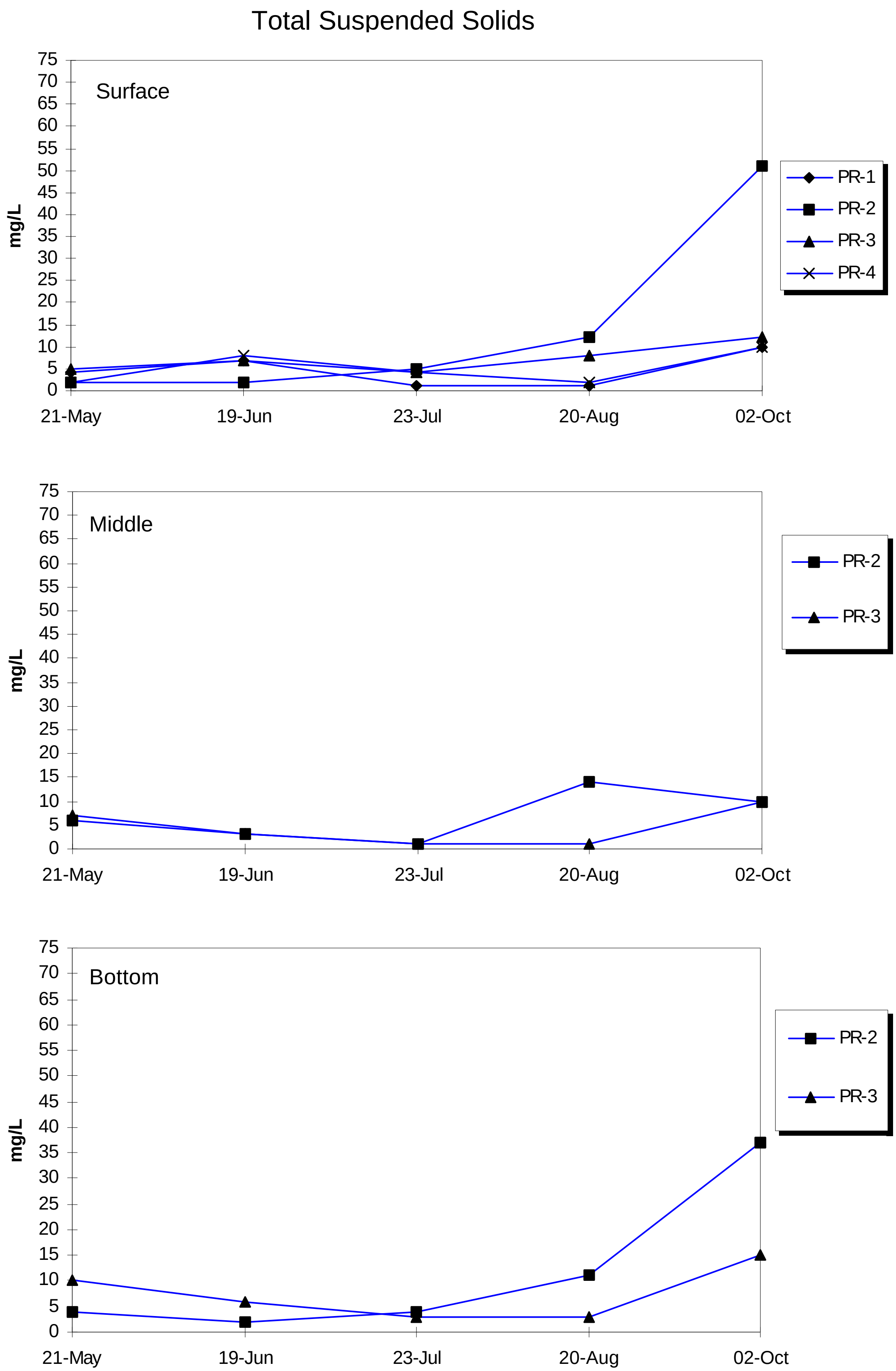

Figure 3-24. Total suspended solids in surface, middle, and bottom waters of Prompton Reservoir in 2002

3.2.10 Biochemical Oxygen Demand

Biochemical oxygen demand (BOD) is a measure of the oxygen-depleting burden imposed by organic material present in water. BOD concentrations in the water column of Prompton Reservoir were relatively low in 2002 (Fig. 3-25). Throughout the monitoring period, concentrations measured at 65% of all stations and depths were typically less than the method detection limit (2-mg/L). BOD levels at all stations and depths in the water column averaged 2.48-mg/L throughout the monitoring period. Measures of BOD throughout the water column were typically higher at station PR-2 and averaged 3.0-mg/L from May through October.

BOD measured in 2002 and historical data collected from over the past 22 years were analyzed for seasonal trends. The trend analysis was conducted for spring and summer periods, separately for stations representative of the reservoir (PR-2) and downstream (PR-4) monitoring. None of the analyses indicated that consistent changes in BOD have occurred in either season (Figs. 3-26 and 3-27). Regression lines were not significant ($P < 0.05$) for either the reservoir or downstream sites.

A seasonal trend analysis of BOD was also conducted for individual stations of Prompton Reservoir, combining 2002 and historical data. The Mann-Kendall statistic was applied to station data collected over the past 21 years, separately for spring (April to June) and summer (July to October) seasons. Stations included in the analysis represented upstream sources (PR-1) and the main reservoir (PR-2 and PR-3) and the downstream station (PR-4).

BOD does not appear to have significantly changed in the Prompton Reservoir drainage over the past two decades. None of the seasonal trends were significant for any of the upstream and reservoir stations (Table 3-8).

Table 3-8. Seasonal trends of total BOD concentration at individual stations of Prompton Reservoir calculated with the Mann-Kendall Statistic.

Station	# of Years	Spring		Summer	
	Spring/Summer	P Level	Rate(mg/L)	P Level	Rate (mg/L)
Surface Water					
PR-1	20/21	NS	-0.0033	NS	-0.0001
PR-2	20/21	NS	-0.0137	NS	-0.0567
PR-3	20/21	NS	0	NS	0.0336
PR-4	7/8	NS	0	NS	-0.0083

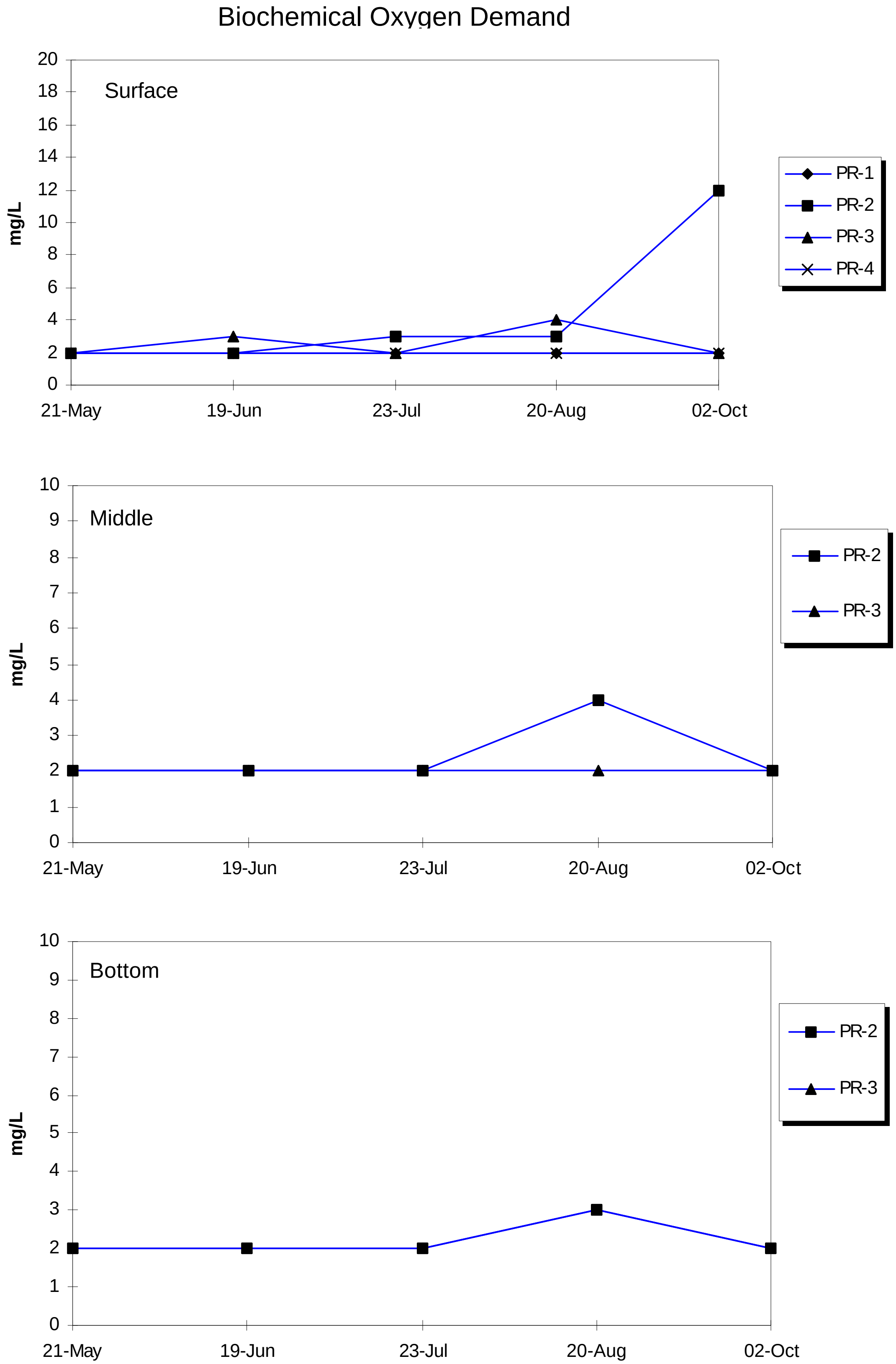

Figure 3-25. Biochemical oxygen demand in surface, middle, and bottom waters of Prompton Reservoir in 2002

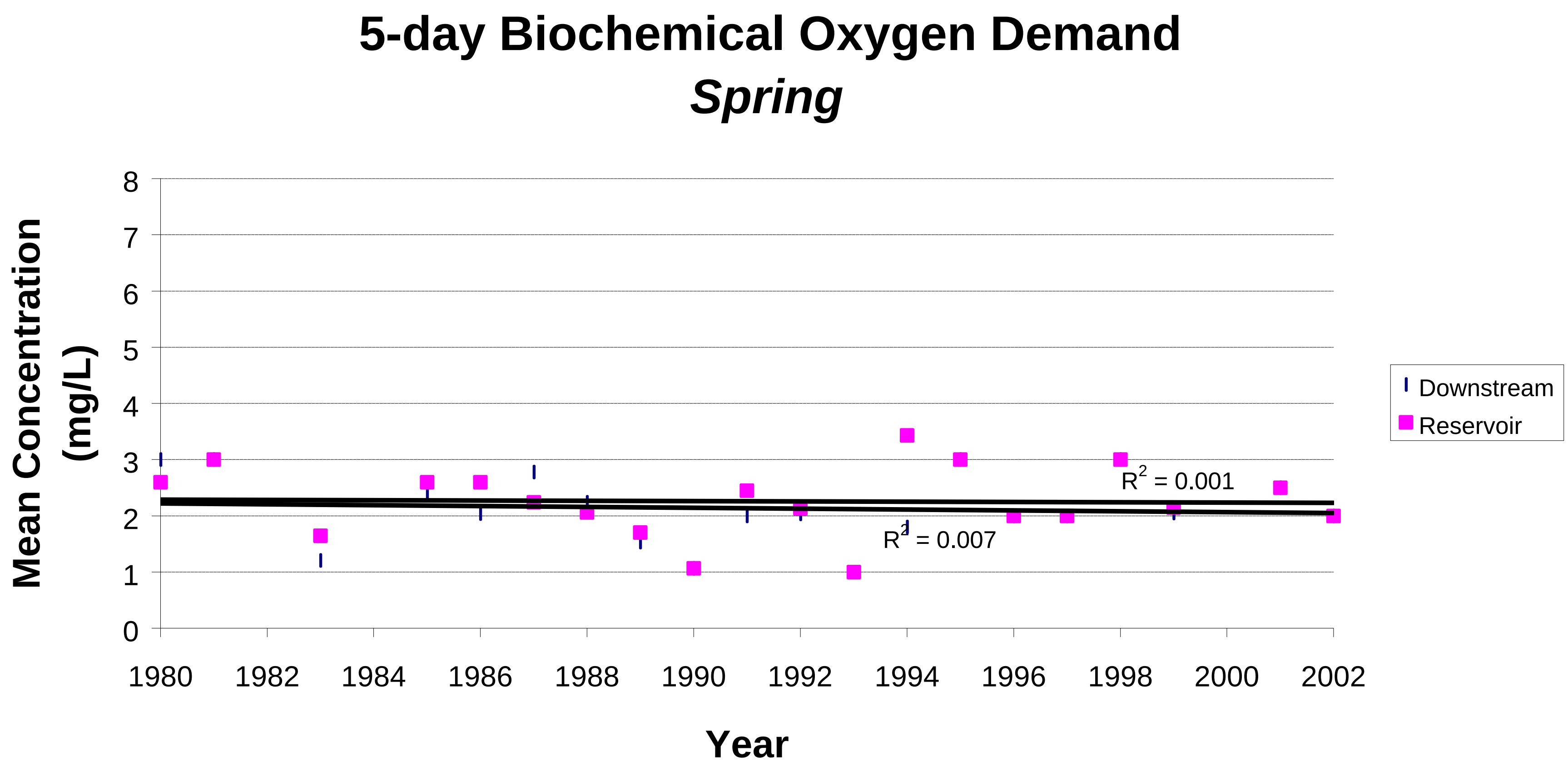

Figure 3-26. Seasonal trend analysis for five-day biochemical oxygen demand during spring at Prompton Reservoir

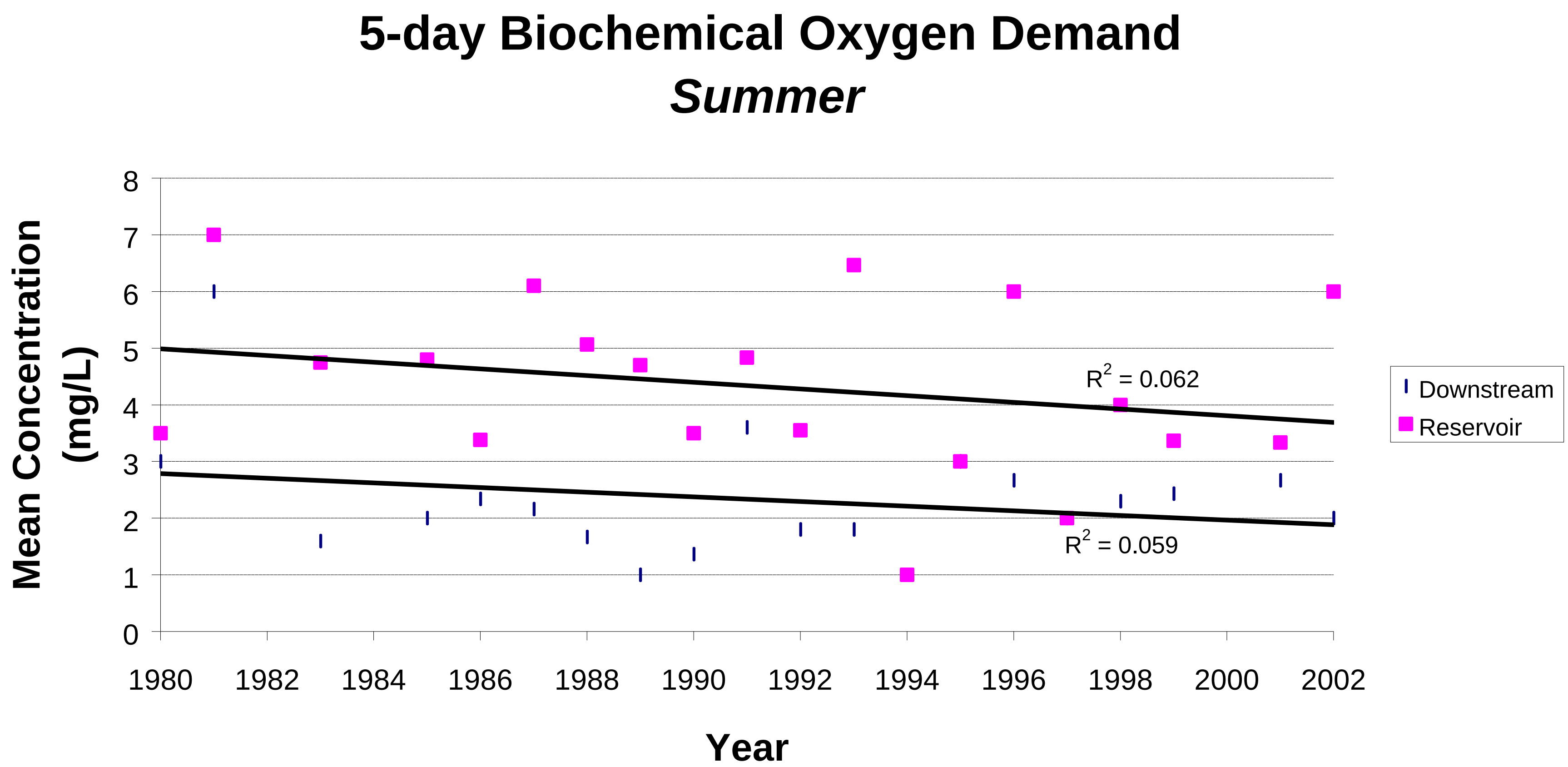

Figure 3-27. Seasonal trend analysis for five-day biochemical oxygen demand during summer at Prompton Reservoir

3.2.11 Alkalinity

Alkalinity is a measure of the acid-neutralizing capacity of water. Alkalinity in the water column of Prompton Reservoir for the most part was relatively low during 2002. The PADEP water quality standard for alkalinity is a minimum concentration 20 mg/L except where natural conditions are less. Concentrations measured at all stations and depths during the monitoring period averaged 21.3-mg/L and ranged from 10 to 60-mg/L (Fig. 3-28). Alkalinity concentrations were below the PADEP minimum concentration of 20 mg/L during May, June, and July. The natural alkalinity of water is largely dependent on the underlying geology and soils within the surrounding watershed. The low alkalinity measured at Prompton Reservoir probably resulted from the regional geology.

3.2.12 Chlorophyll *a*

Chlorophyll *a* readings in the water column of Prompton Reservoir were consistently low during 2002. Concentrations measured at all stations and depths averaged 4.7-mg/m^3 and ranged from 0.96 to 13.98--mg/m^3 throughout the monitoring (Fig.3-29). Chlorophyll *a* at PR-2 was generally higher averaging 5.67-mg/m^3.

3.2.13 Hydrogen Sulfide

Hydrogen sulfide was monitored at station PR-4 this year due to concern that elevated levels from the reservoir were being transported downstream. During the summer a rotten egg odor is not uncommon in the vicinity of Prompton Reservoir. The odor of water with a concentration as little as 0.5-mg/L of hydrogen sulfide is detectable by most people. Concentrations less than 1-mg/L give the water a "musty" or "swampy" odor. A 1-2 mg/L hydrogen sulfide concentration gives water a "rotten egg" odor. Hydrogen sulfide was only detected in May at a level of 0.4-mg/L. The remaining samples were below detection limits of 0.4 and 0.025-mg/L.

3.3 TROPHIC STATE DETERMINATION

Carlson's (1977) trophic state index (TSI) is a method of quantitatively expressing the magnitude of eutrophication for a lake. The trophic state analysis calculates separate indices for eutrophication based on measures of total phosphorus, chlorophyll *a*, and secchi disk. Index values for each parameter range on the same scale from 0 (least enriched) to 100 (most enriched). The resulting indices can also be compared to qualitative threshold values that correspond to levels of eutrophication: oligotrophic (TSI < 40), mesotrophic (TSI's from 40 to 50), mesoeutrophic (TSIs from 50 to 60), and eutrophic (TSI > 60).

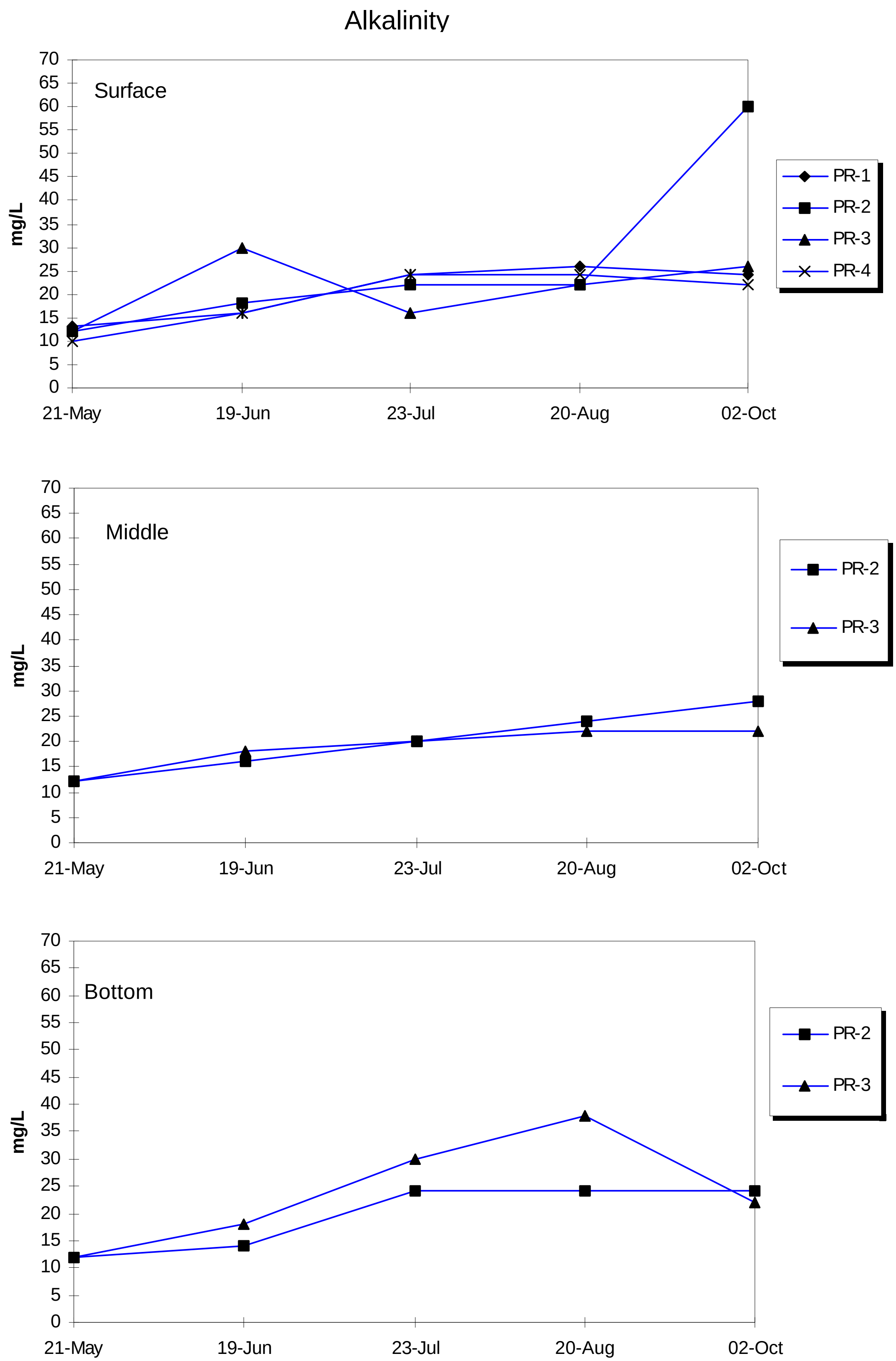

Figure 3-28. Alkalinity in surface, middle, and bottom waters of Prompton Reservoir in 2002. The PADEP water quality standard for alkalinity is a minimum concentration of 20 mg/L.

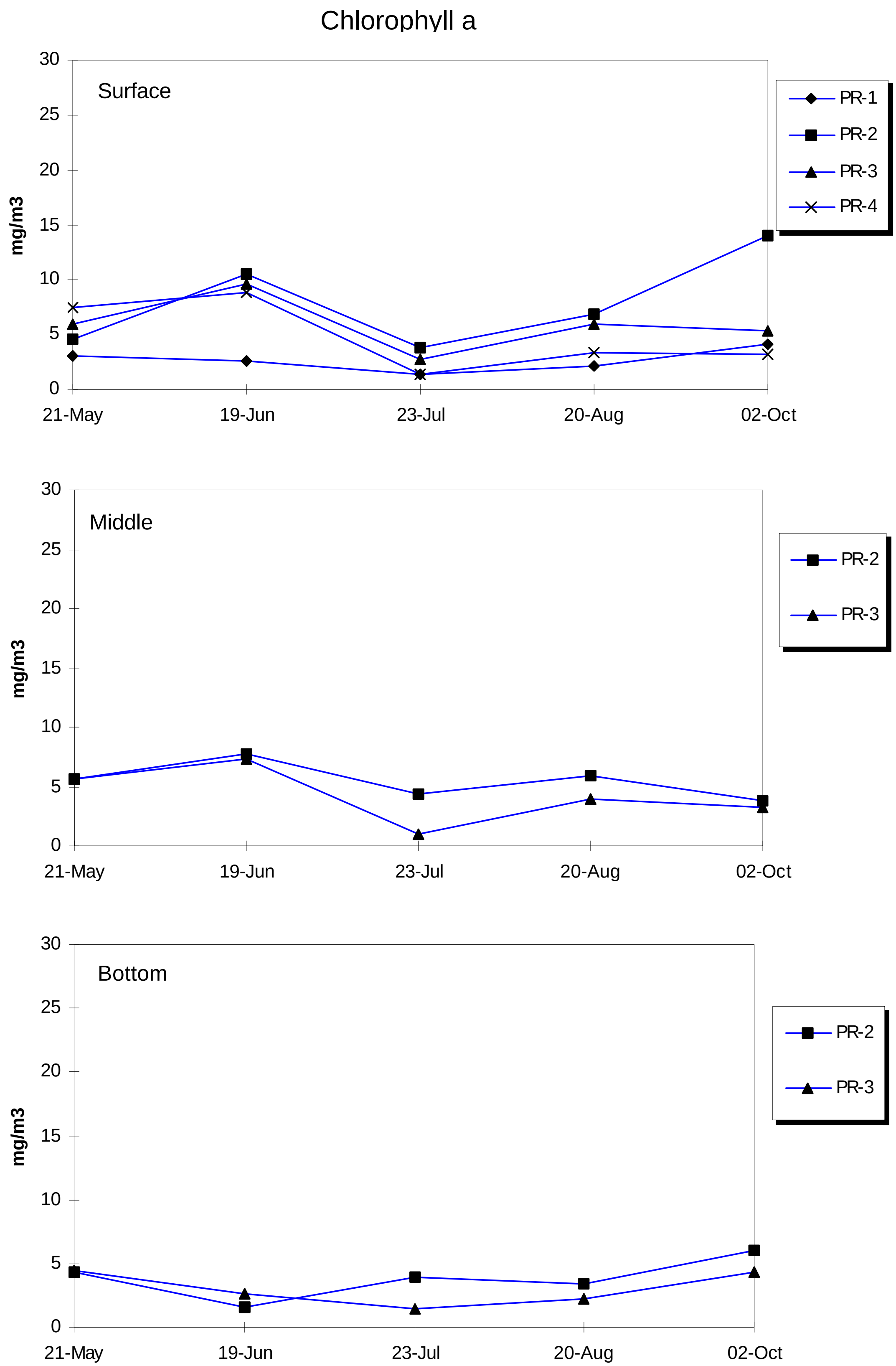

Figure 3-29. Chlorophyll *a* (mg/m^3) in surface, middle, and bottom waters of Prompton Reservoir in 2002

TSIs calculated for measures of secchi disk depth classified Prompton Reservoir as mesoeutrophic during 2002 (Fig. 3-30). The TSI values ranged from 51 to 60.

TSIs calculated for measures of total phosphorus classified Prompton Reservoir as mesoeutrophic in the beginning of the summer with TSI value of 51 (Fig. 3-30). The TSI values increased throughout the summer classifying the lake as eutrophic. The TSI values ranged from 61 to 83 over the monitoring period.

TSIs calculated for measures of chlorophyll *a* classified Prompton Reservoir as mesotrophic for most of sampling period of 2002 (Fig. 3-30). The values ranged from 42 to 49. During June and October, the TSI values increased to 53 classifying the lake as mesoeutrophic.

Carlson (1977) warned against averaging TSI values estimated for different parameters, and instead suggested giving priority to chlorophyll *a* in the summer and to phosphorus in the spring, fall, and winter. With this in mind, our estimation of the trophic state of the reservoir based on TSI's was mesoeutrophic/eutrophic during 2002.

The EPA (1983) also provides criteria for defining the trophic conditions of lakes of the north-temperate zone based on concentrations of total phosphorus, chlorophyll *a*, and secchi depth (Table 3-9). Concentrations of total phosphorus classified the lake as eutrophic. Concentrations of chlorophyll *a* ranged from mesotrophic (May) to eutrophic (June). In July, the lake was classified as oligootrophic and in August went back to being mesotrophic and stayed that way throughout October. Secchi disk depth classified the lake as eutrophic. Taking into account the general agreement between the EPA classifications with that of the TSIs, the trophic condition of Prompton Reservoir was borderline eutrophic.

Table 3-9. EPA trophic classification criteria and average monthly measures for Prompton Reservoir in 2002

Water Quality Variable	**Oligo-trophic**	**Meso-trophic**	**Eutrophic**	**May**	**Jun**	**July**	**Aug**	**Oct**
Total phos. (µg/l)	< 10	10-20	> 20	25	25	50	85	240
Chlorophyll (mg/m^3)	< 4	4-10	> 10	5.3	10.1	3.3	6.4	9.7
Secchi depth (m)	> 4	2-4	< 2	1.5	1.9	1.2	1.0	1.1

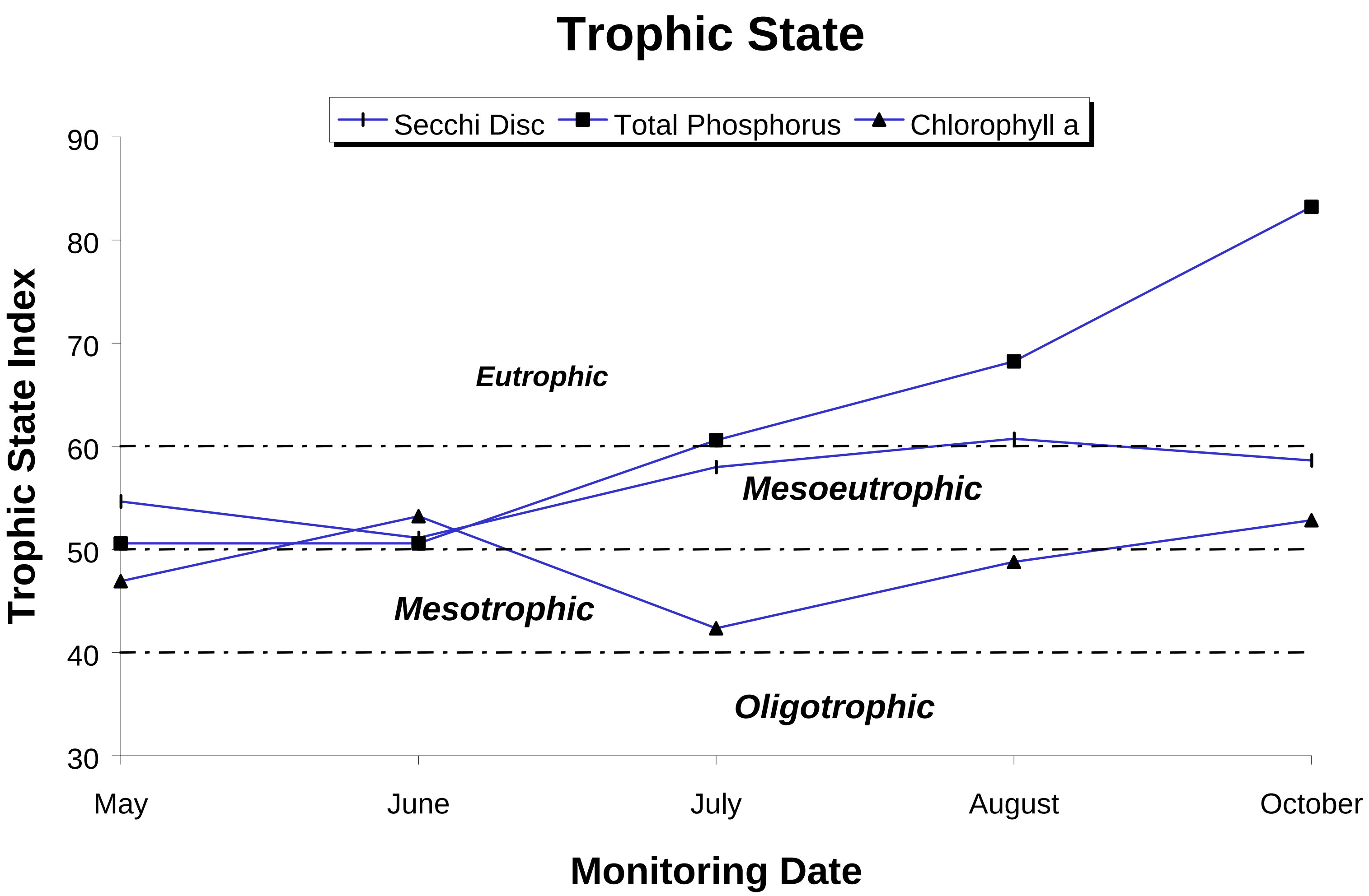

Figure 3-30. Trophic state indices calculated from secchi disk depth, concentrations of chlorophyll *a*, and total phosphorus measured in surface water of Prompton Reservoir during 2002

3.4 RESERVOIR BACTERIA MONITORING

Three coliform parameters were monitored at Prompton Reservoir during 2002: total coliform, fecal coliform and fecal streptococcus (Table 3-10; Figs. 3-31, 3-32, and 3-33). Coliform counts were conducted for surface waters at stations upstream of the reservoir (PR-1), within the reservoir (PR-2 and PR-3), and downstream of the reservoir (PR-4).

Total coliform contamination was relatively low throughout the monitoring period with the exception of 2 October (Fig. 3-31). Counts on 2 October ranged from 2960 to 4400-colonies/100-ml (Table 3-10).

Fecal coliform contamination was low throughout the reservoir with the exception of PR-1, which had counts of 720-colonies/100-ml on 23 July and 640-colonies/100-ml on 20 July (Fig. 3-32 and Table 3-10). These were the highest counts through out the monitoring period. Most sample counts ranged from below the detection limit (10) to 160-colonies/100-mls.

Table 3-10. Bacteria counts (colonies/100 ml) at Prompton Reservoir during 2002. Shaded values exceed the Pennsylvania Department of Health water quality standard for bathing beach of 1,000 fecal coliform colonies/100-ml.

Station	Date	Total Coliform (TC)	Fecal Coliform (FC)	Fecal Strep (FS)	FC/FS
PR-1S	21-May	160	30	140	0.21
	19-Jun	130	100	130	0.77
	23-Jul	440	720	440	1.64
	20-Aug	1670	640	1040	0.62
	2-Oct	2960	160	200	0.80
PR-2S	21-May	250	40	190	0.21
	19-Jun	30	10	30	0.33
	23-Jul	10	< 10	10	NC
	20-Aug	40	10	< 10	NC
	2-Oct	4400	< 10	< 10	NC
PR-3S	21-May	80	10	80	0.13
	19-Jun	10	10	10	1.00
	23-Jul	10	< 10	10	NC
	20-Aug	10	< 10	< 10	NC
	2-Oct	4120	10	< 10	NC
PR-4S	21-May	110	< 10	80	NC
	19-Jun	130	110	130	0.85
	23-Jul	30	20	20	1.00
	20-Aug	60	140	60	2.33
	2-Oct	3200	30	30	1.00

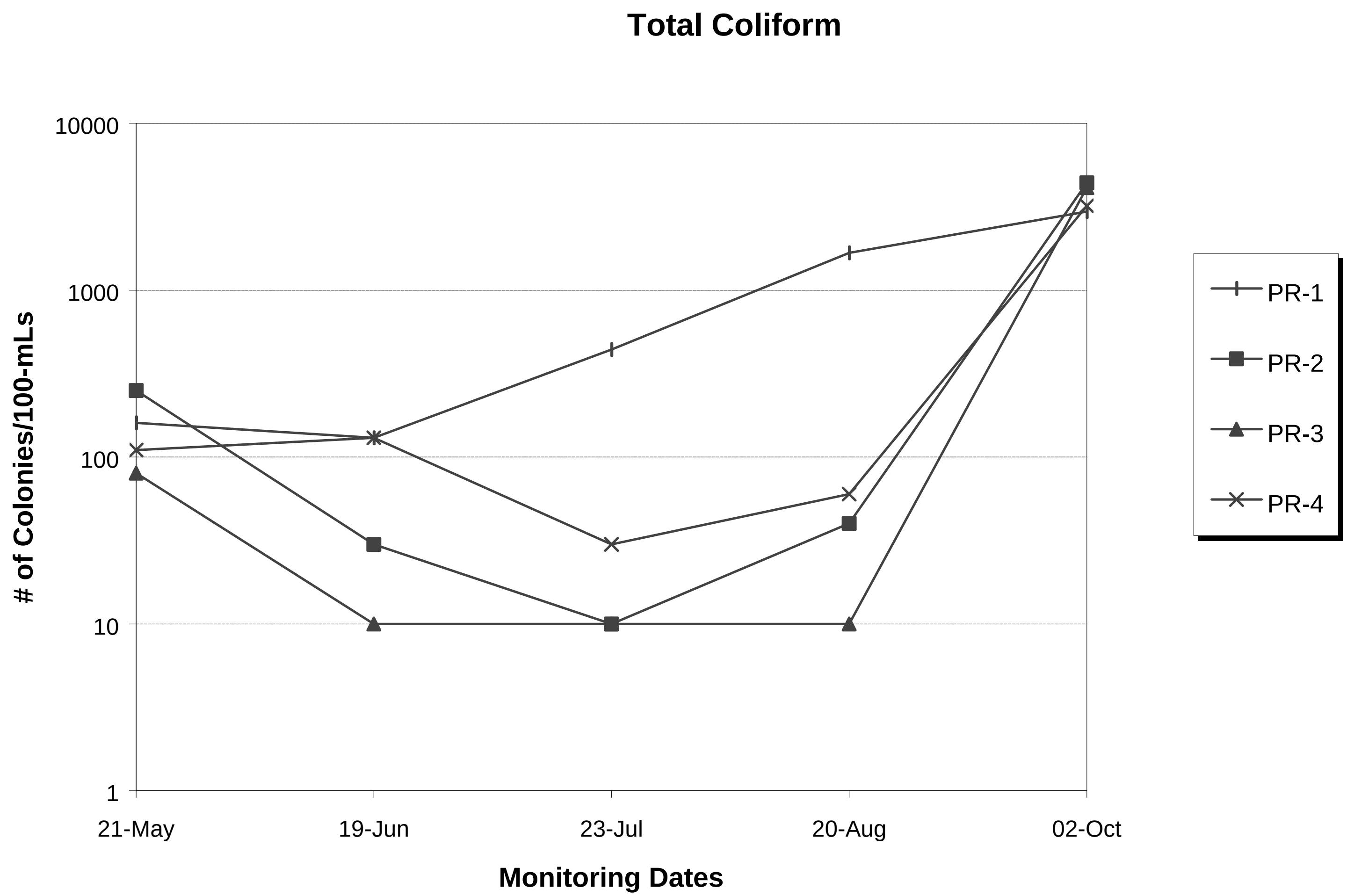

Figure 3-31. Total coliform counts in surface waters of Prompton Reservoir in 2002

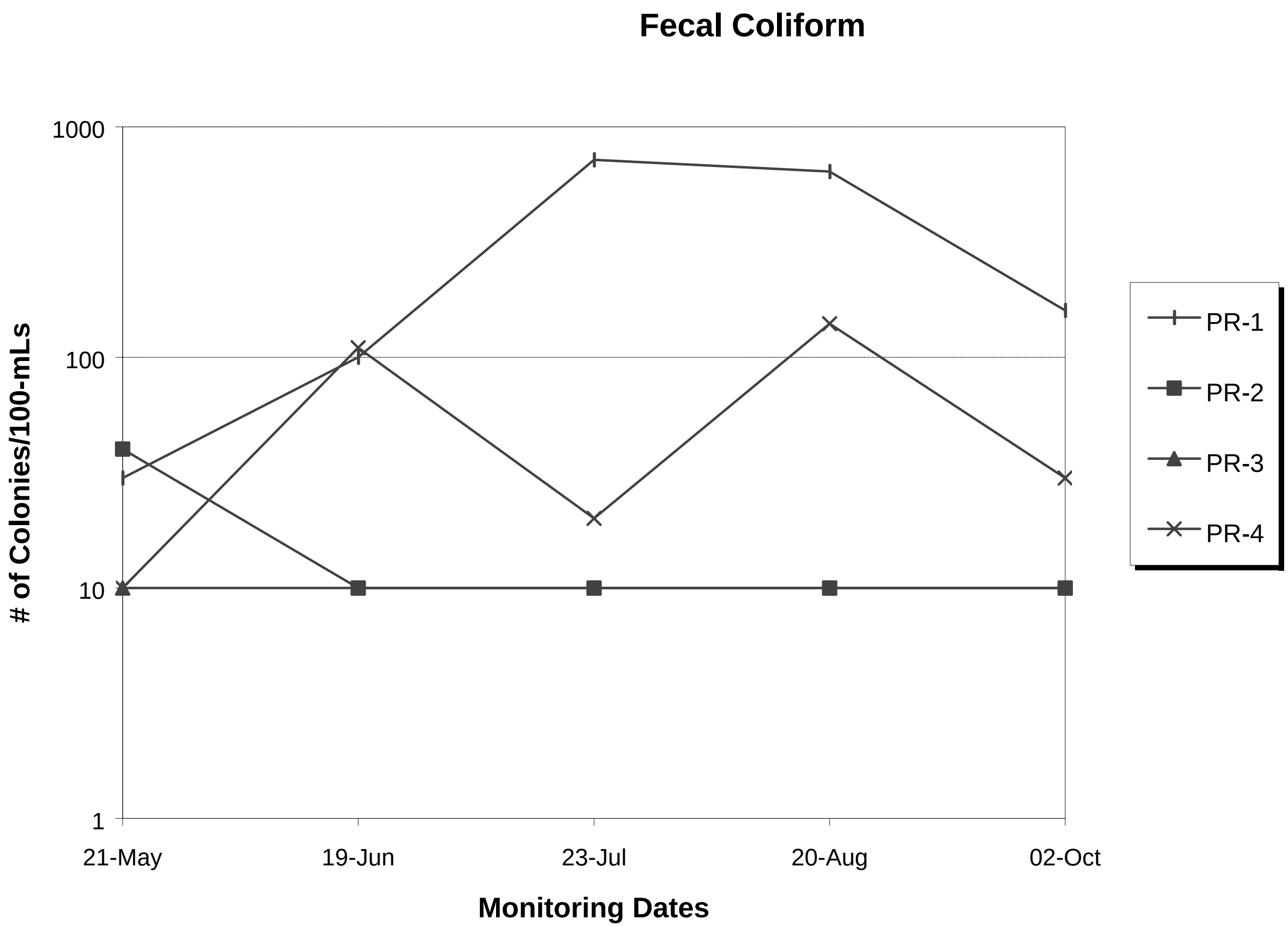

Figure 3-32. Fecal coliform counts in surface waters of Prompton Reservoir in 2002. The PADEP water quality standard for fecal coliform is less than 200 colonies/100 mls.

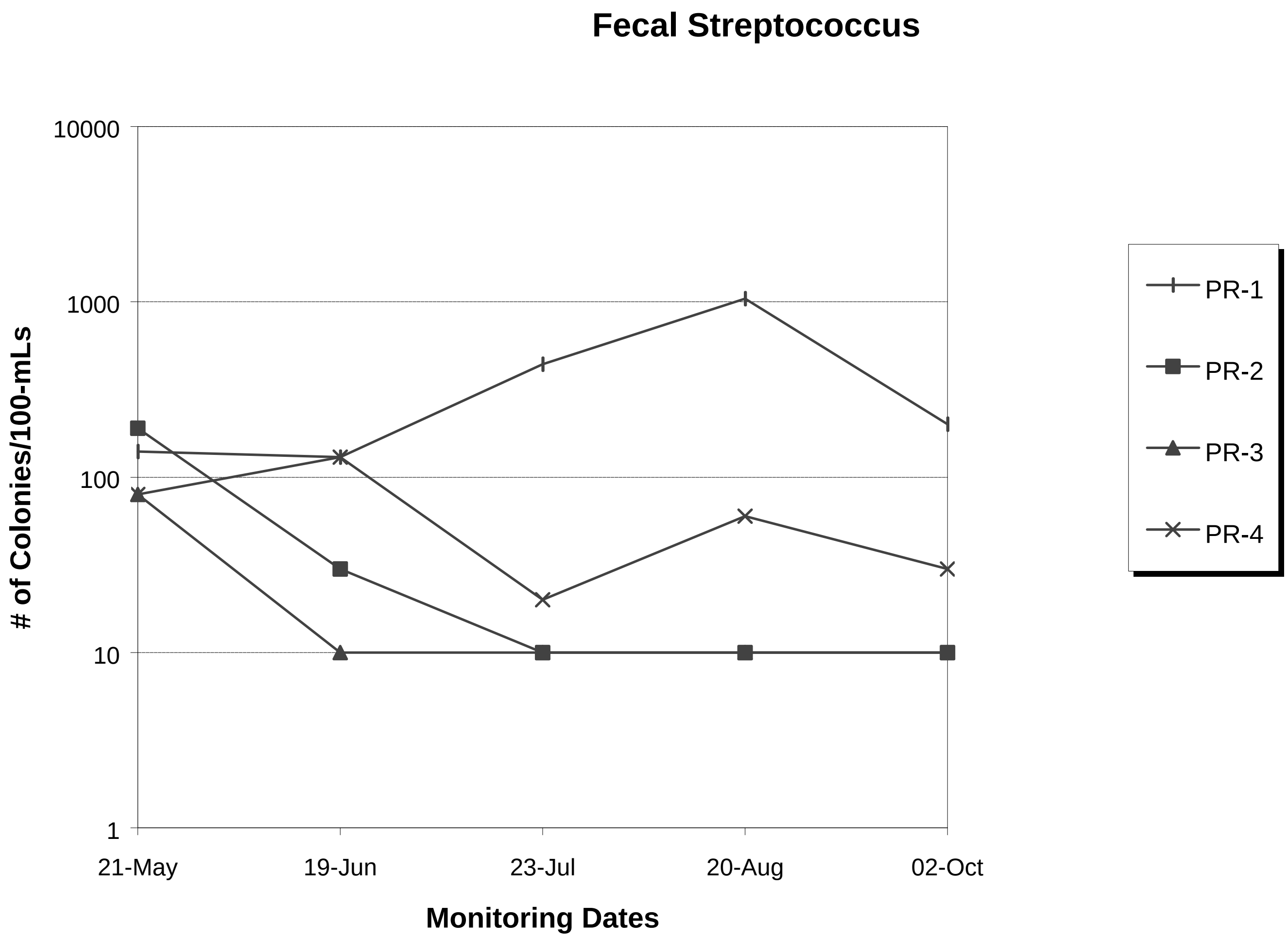

Figure 3-33. Fecal streptococcus counts in surface waters of Prompton Reservoir in 2002

Fecal streptococcus counts were low throughout the reservoir with the exception of the station upstream PR-1 (Fig. 3-33). The counts at station PR-1 ranged from 130 to 1040-colonies/100-mls (Table 3-10). At the other stations the counts ranged from below the detection limit (10) to 190-colonies/100-mls.

Bacteria contamination was low at Prompton Reservoir with respect to PADEP water quality standards. The PADEP standard for bacteria contamination is a geometric mean among fecal coliform samples of not greater than 200 colonies/100-ml. In all months, the geometric means calculated among samples were less than 200 colonies/100-ml (Fig 3-34 and Table 3-11).

Table 3-11. Summary statistics of fecal coliform counts (colonies/100-ml) among all stations of Prompton Reservoir during 2002. (PADEP water quality standard for fecal coliforms is a geometric mean not greater than 200 colonies/100-ml.)

Date	Geometric Mean	Arithmetic mean	Maximum Count
5/21	18.6	22.5	40.0
6/19	32.4	57.5	110.0
7/23	34.6	190.0	720.0
8/20	54.7	200.0	640.0
10/2	26.3	52.5	160.0

The ratio of fecal coliform to fecal streptococcus counts has been used to identify sources of bacteria contamination (McComas 1993). The ratio is characteristic for several animal species and certain waste disposal practices; for human waste, the ratio is 4 to 1. Use of the ratio was limited to the extent that counts at most stations were at or less than method detection limits for one or both coliform parameters. Out of a total of 20 perspective ratios, only 13 were calculated (Table 3-10). At station PR-1 the ratio was calculated at every sampling event and ranged from 0.21 to 1.64. Among the four stations monitored, there were five ratios within the range that suggested the source was human waste.

Flow data from USGS gauging stations within the Prompton Reservoir watershed (Aldenville) were analyzed to qualitatively correlate precipitation events with coliform bacteria contamination (Figs. 2-2 through 2-7). All of the monitoring at Prompton was conducted near base flow conditions. The fecal coliform counts may have high in July and August due to the drought during the summer of 2002.

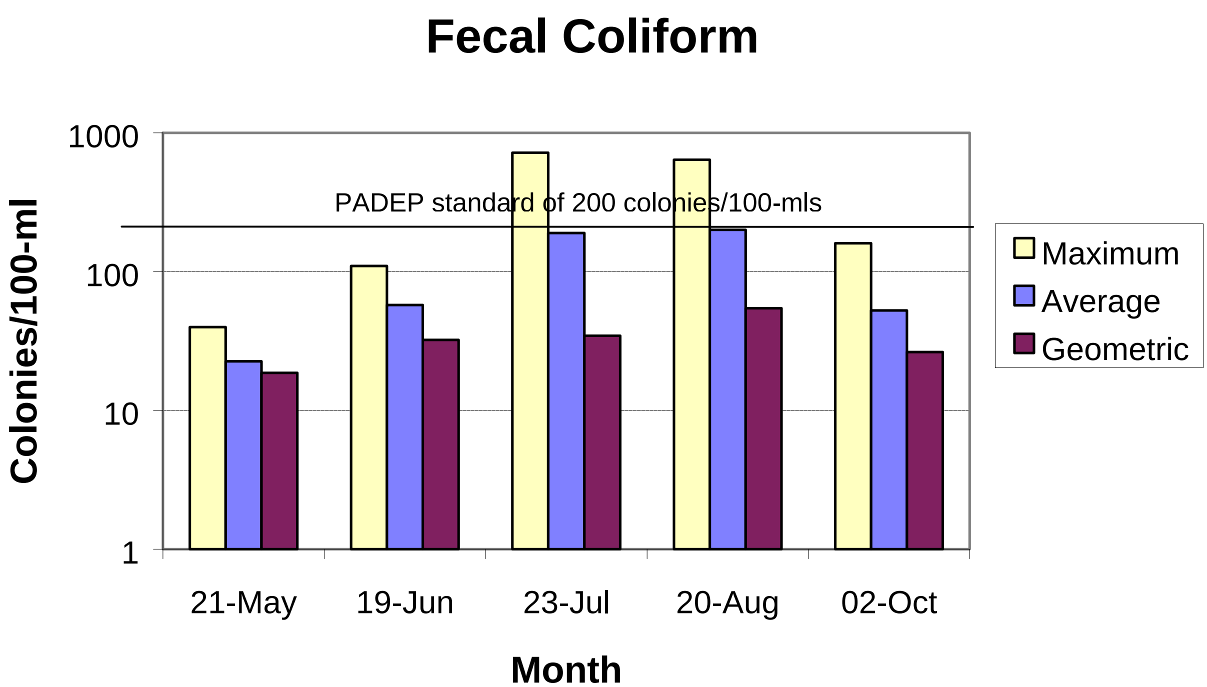

Figure 3-34. Maximum, average, and geometric mean of fecal coliform counts (colonies/ 100-ml) for all stations monitored at Prompton Reservoir in 2002

Fecal coliform counts for 2002 and historical data from the past 22 years were analyzed for seasonal trends. The trend analysis was conducted for spring and summer seasons separately for stations representative of the reservoir (PR-2) and downstream (PR-4). From the analysis, fecal coliform contamination appears to have decreased within the reservoir during the summer season. The decreasing trend was significant ($R^2 = 0.218$; $P < 0.05$);(Figs 3-35 and 3-36). Significant trends were not determined downstream of the reservoir in either season, or for the reservoir in the spring.

Seasonal trend analyses of total and fecal coliform bacteria were also conducted for individual stations of Prompton Reservoir, combining 2002 and historical data. The Mann-Kendall statistic was applied to station data collected over the past 18 years or more, separately for spring (April to June) and summer (July to October) seasons. Stations included in the analysis represented upstream sources (PR-1) and main reservoir (PR-2 and PR-3) and the downstream station (PR-4). From all the analysis for total coliform bacteria, there were no significant trends (Table 3-12). For fecal coliforms one trend was determined to be significant; station PR-2 in the summer (Table 3-13). The rate of decrease estimated for the trend is 1.46 colonies/100-ml/year.

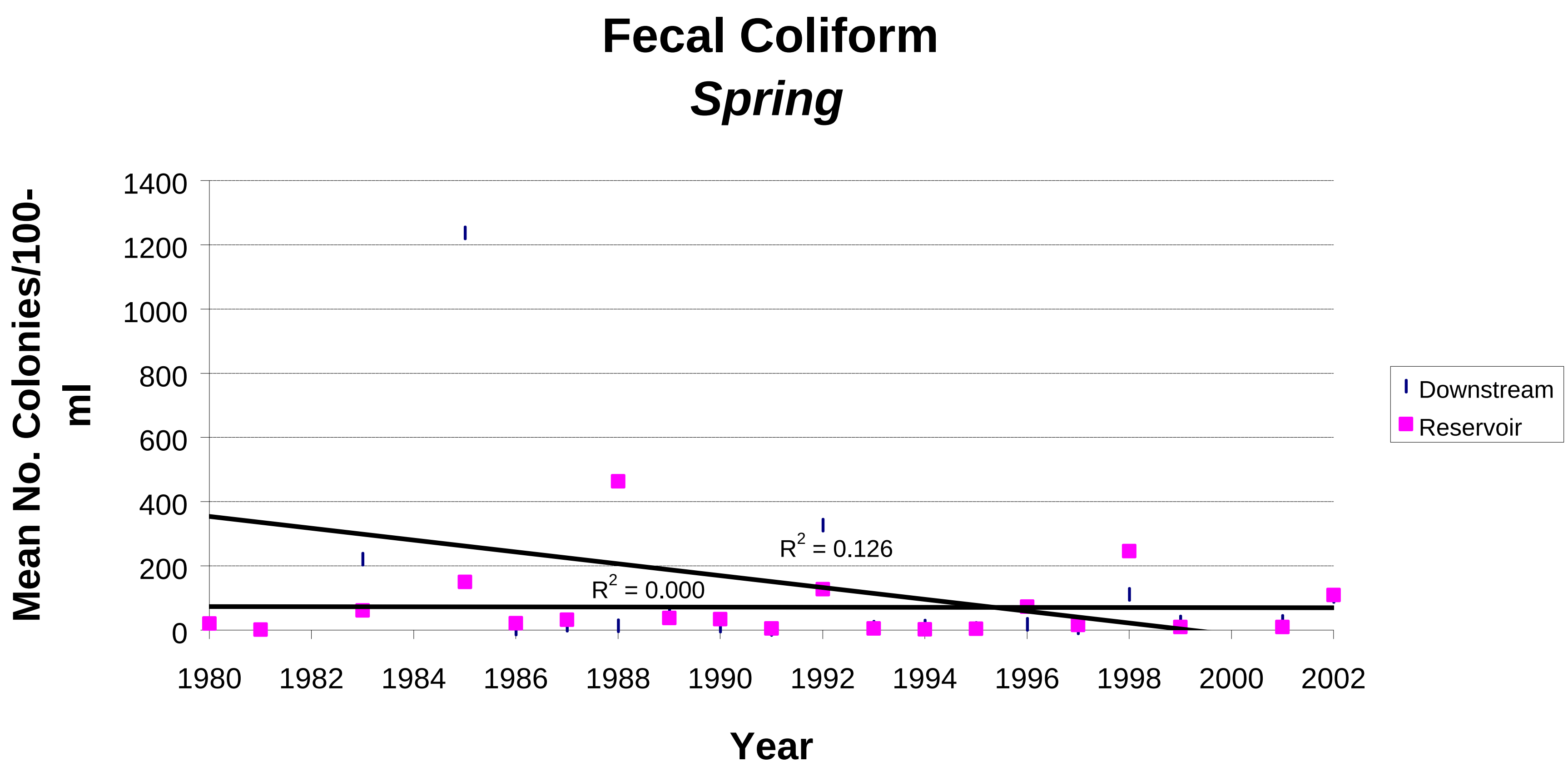

Figure 3-35. Seasonal trend analysis for fecal coliforms in surface waters during spring at Prompton Reservoir

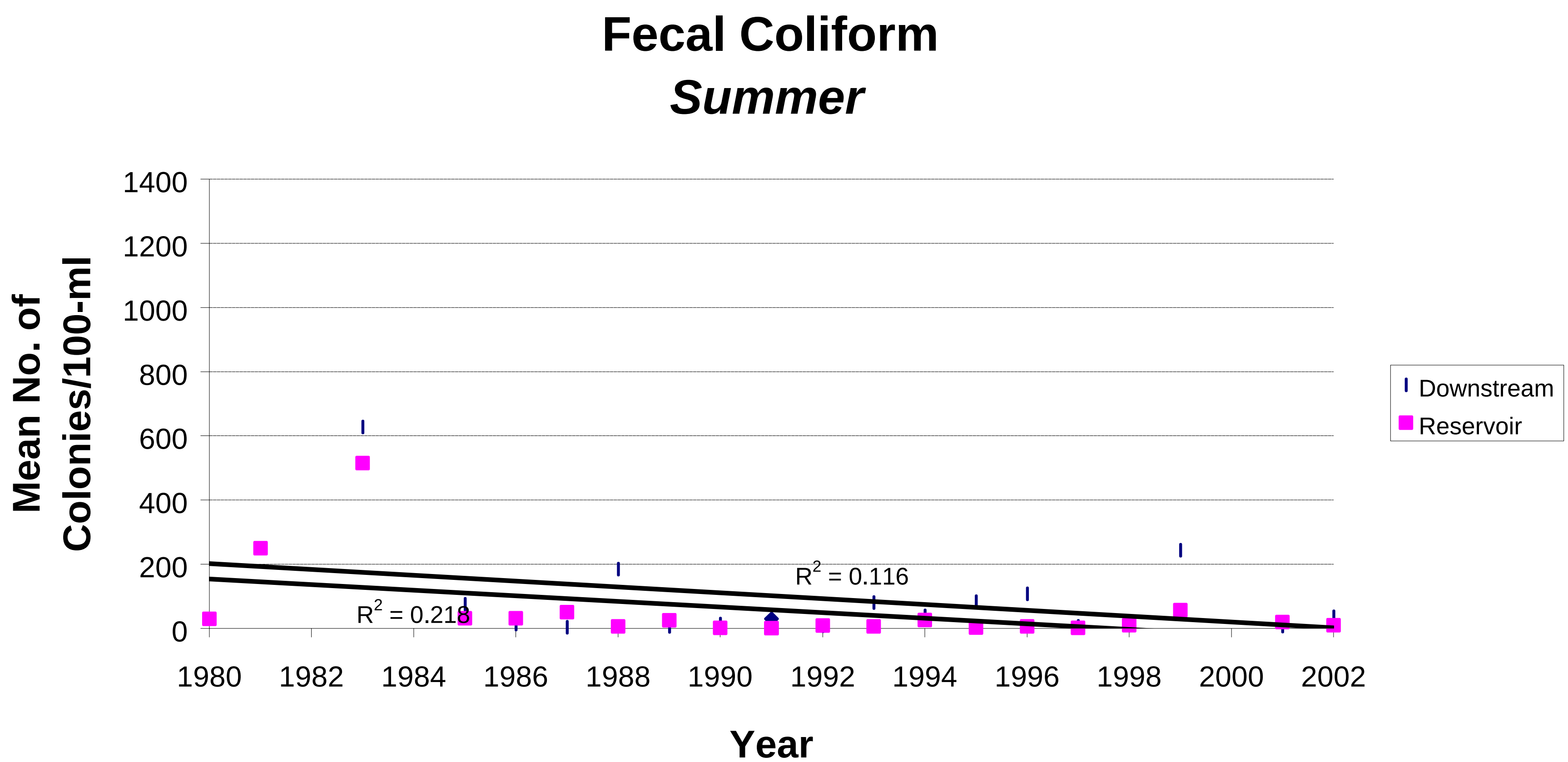

Figure 3-36. Seasonal trend analysis for fecal coliforms in surface waters during summer at Prompton Reservoir

Table 3-12. Seasonal trends of fecal coliforms/100ml at individual stations of Prompton Reservoir calculated with the Mann-Kendall Statistic.					
Station	**# of Years Spring/Summer**	**Spring**		**Summer**	
		P Level	**Rate**	**P Level**	**Rate**
Surface Water					
PR-1	20/21	NS	6.5530	NS	10.4667
PR-2	20/21	NS	-0.1783	< 0.05	-1.4582
PR-3	18/19	NS	-0.7273	NS	-1.0625
PR-4	7/8	NS	4.5000	NS	-6.0833

Table 3-13. Seasonal trends of total coliforms/100ml at individual stations of Prompton Reservoir calculated with the Mann-Kendall Statistic.					
Station	**# of Years Spring/Summer**	**Spring**		**Summer**	
		P Level	**Rate**	**P Level**	**Rate**
Surface Water					
PR-1	20/21	NS	2.8175	NS	-18.3299
PR-2	20/21	NS	0.8056	NS	-13.1944
PR-3	18/19	NS	-6.3333	NS	-21.1905
PR-4	7/8	NS	7.1667	NS	25.2778

3.5 SEDIMENT PRIORITY POLLUTANT MONITORING

Sediment samples were collected at stations PR-3 and analyzed for priority pollutant contaminants, Group 1 – PCB's, pesticides and volatile organic compounds. Resulting concentrations were compared to New Jersey Soil Cleanup Criteria (NJDEP 1999). The NJDEP criteria are human health based with categories addressing residential and non-residential settings, and impacts to groundwater. For our comparison, we reported the most conservative of the two criteria.

There was only one parameter that was detected of the 93 priority pollutant contaminants analyzed from Prompton Reservoir sediments (Table 3-14). The volatile organic compound methylene chloride (DCM) was found at station PR-3 with a value of 406 ppb. However, methylene chloride is a common laboratory contaminant and is therefore not considered a contaminant of concern at Prompton Reservoir.

Table 3-14. PCB's, pesticides, and volatile organic compounds (Group 1) measured in sediments of Prompton Reservoir in 2002					
Units	**Residential Direct Contact Soil Cleanup Criteria**	**Non-Residential Direct Contact Soil Cleanup Criteria**		**Method Detection Limit**	**PR-3**
Percent Solids			ppb	0.1	22.4
PCBs - Method 8082					
Aroclor-1016			ppb	100	ND
Aroclor-1221			ppb	100	ND
Aroclor-1232			ppb	100	ND
Aroclor-1242			ppb	100	ND
Aroclor-1248			ppb	100	ND
Aroclor-1254			ppb	100	ND
Aroclor-1260			ppb	100	ND
Pesticides - Method 8081A					
4,4'-DDD	3000	12000	ppb	4	ND
4,4'-DDE	2000	9000	ppb	4	ND
4,4'-DDT	2000	9000	ppb	4	ND
alpha-BHC			ppb	4	ND
a-Chlordane			ppb	4	ND
Aldrin	40	170	ppb	4	ND
beta-BHC			ppb	4	ND
Chlordane, technical			ppb	40	ND
delta-BHC			ppb	4	ND
Dieldrin	42	180	ppb	4	ND
Endosulfan I	340000	6200000	ppb	4	ND
Endosulfan II	340000	6200000	ppb	4	ND
Endrin	17000	310000	ppb	4	ND
Endrin aldehyde			ppb	4	ND
Endrin ketone			ppb	4	ND
Endosulfan Sulfate			ppb	4	ND
gamma-BHC (Lindane)	520	2200	ppb	4	ND
g-Chlordane			ppb	4	ND
Heptachlor	150	650	ppb	4	ND
Heptachlor epoxide			ppb	4	ND
Methoxychlor	280000	5200000	ppb	10	ND
Toxaphene	100	200	ppb	200	ND
Volatile Organic Compounds - Method 8260B					
1,1,1,2-Tetrachloroethane	170000	310000	ppb	1	ND
1,1,1-Trichloroethane	210000	1000000	ppb	1	ND
1,1,2,2-Tetrachloroethane	34000	70000	ppb	1	ND
1,1,2-Trichloroethane	22000	420000	ppb	1	ND
1,1-Dichloroethane	570000	1000000	ppb	1	ND

Table 3-14. (Continued)

Units	Residential Direct Contact Soil Cleanup Criteria	Non-Residential Direct Contact Soil Cleanup Criteria		Method Detection Limit	PR-3
1,1-Dichloroethene	8000	150000	ppb	1	ND
1,1-Dichloropropene			ppb	1	ND
1,2,3-Trichlorobenzene			ppb	1	ND
1,2,3-Trichloropropane			ppb	1	ND
1,2,4-Trichlorobenzene	68000	1200000	ppb	1	ND
1,2,4-Trimethylbenzene			ppb	1	ND
1,2-Dibromo-3-chloropropane			ppb	1	ND
1,2-Dichloroethane	6000	24000	ppb	1	ND
1,2-Dichlorobenzene	5100000	10000000	ppb	1	ND
1,2-Dichloropropane	10000	43000	ppb	1	ND
1,2-Dibromoethane			ppb	1	ND
1,3,5-Trimethylbenzene			ppb	1	ND
1,3-Dichlorobenzene	5100000	10000000	ppb	1	ND
1,3-Dichloropropane			ppb	1	ND
1,4-Dichlorobenzene	570000	10000000	ppb	1	ND
2,2-Dichloropropane			ppb	1	ND
2-Chlorotoluene			ppb	1	ND
2-Hexanone			ppb	10	ND
4-Chlorotoluene			ppb	1	ND
Acetone	1000000	1000000	ppb	10	ND
Benzene	3000	13000	ppb	1	ND
Bromochloromethane			ppb	1	ND
Bromodichloromethane	11000	46000	ppb	1	ND
Bromobenzene			ppb	1	ND
Bromoform	86000	370000	ppb	1	ND
Bromomethane	79000	1000000	ppb	1	ND
c-1,2-Dichloroethene	79000	1000000	ppb	1	ND
c-1,3-Dichloropropene	4000	5000	ppb	1	ND
Carbon Tetrachloride	2000	4000	ppb	1	ND
Chlorobenzene	37000	680000	ppb	1	ND
Chloroethane			ppb	1	ND
Chloroform	19000	28000	ppb	1	ND
Chloromethane	520000	1000000	ppb	1	ND
Methylene Chloride (DCM)	49000	210000	ppb	1	406
Dibromochloromethane	110000	1000000	ppb	1	ND
Dibromomethane			ppb	1	ND
Dichlorofluoromethane			ppb	1	ND
Ethylbenzene	1000000	1000000	ppb	1	ND
Hexachloro1,3-butadiene	1000	21000	ppb	1	ND
Isopropylbenzene (cumene)			ppb	1	ND

Table 3-14. (Continued)					
Units	**Residential Direct Contact Soil Cleanup Criteria**	**Non-Residential Direct Contact Soil Cleanup Criteria**		**Method Detection Limit**	**PR-3**
m,p-Xylene			ppb	1	ND
2-Butanone(MEK)	1000000	1000000	ppb	10	ND
4-Methyl-2-pentanone (MIBK)	1000000	1000000	ppb	10	ND
Methyl-tert-butylether (MTBE)			ppb	1	ND
n-ButylBenzene			ppb	1	ND
n-Propylbenzene			ppb	1	ND
Naphthalene	230000	4200000	ppb	1	ND
o-Xylene			ppb	1	ND
p-Isopropyltoluene			ppb	1	ND
Tetrachloroethene	4000	6000	ppb	1	ND
sec-Butylbenzene			ppb	1	ND
Styrene	23000	97000	ppb	1	ND
trans-1,2-dichloroethene	1000000	1000000	ppb	1	ND
t-1,3-Dichloropropene	4000	5000	ppb	1	ND
t-Butylalcohol			ppb	10	ND
Trichloroethene	23000	54000	ppb	1	ND
Toluene	1000000	1000000	ppb	1	ND
Trichlorofluoromethane			ppb	1	ND
Vinyl chloride	2000	7000	ppb	1	ND

3.6 DRINKING WATER

Drinking water from the outside spigot of the operations building of Prompton Reservoir was monitored for compliance with PADEP water quality standards for primary and secondary contaminants, and inorganic nitrogen (nitrate and nitrite) and coliform bacteria contaminants during 2002. Drinking water samples were analyzed in duplicate, comprising initial and confirmation samples. For matters of reporting, only if the result of the initial sample was not in compliance with water quality standards, the result of the confirmation sample was also reported.

3.6.1 Primary and Secondary Contaminants

Prompton Reservoir drinking water was in compliance with PADEP water quality standards for all the primary and secondary contaminants (Table 3-15). As part of drinking water compliance monitoring, Safe Drinking Water Act (SDWA) forms 4 for the reporting of results of primary and secondary drinking water contaminants were submitted to appropriate state environmental agencies.

Table 3-15. Concentrations of primary and secondary contaminants in drinking water at Prompton Reservoir in 2002. Shaded values indicate results that exceeded Pennsylvania State drinking water standards; in these instances the result of a second sample is also reported.

Parameter	Sampling Date 13 June	PADEP Regulatory Level	Detection Limits	EPA Method
Aluminum	ND	0.2	0.003	200.7
Antimony	ND	0.006	0.003	200.7
Arsenic	ND	0.05	0.01	200.7
Barium	0.143	2.0	0.005	200.7
Cadmium	ND	0.005	0.001	200.7
Chromium	ND	0.1	0.001	200.7
Copper	0.056	1.3	0.001	200.7
Iron	0.193	0.3	0.002	200.7
Lead	0.004	0.015	0.003	200.7
Magnesium	3.88	NL	0.001	200.7
Manganese	0.003	0.05	0.001	200.7
Mercury	ND	0.002	0.0002	245.1
Nickel	0.001	0.1	0.001	200.7
Selenium	ND	0.05	0.005	200.7
Silver	ND	0.1	0.001	200.7
Sodium	4.582	NL	0.02	200.7
Thallium	ND	0.002	0.006	200.7
Zinc	0.026	5.0	0.003	200.7
Chloride	10.5	250	0.5	300
Cyanide	ND	0.2	0.005	SM 4500CN-I
Fluoride	0.7	2.0	0.1	300
Foaming Agents	ND	0.5	0.01	SM 5540C
PH	7.22	6.5-8.5	+/-0.01	150.1
Sulfate	13	250.0	1.0	300
Total Dissolved Solids	160	500.0	10	160.1

All results, criteria and detection limits are expressed in mg/l except ph which is expressed in positive/negative
ND – Not Detected
NL – Not Listed

3.6.2 Inorganic Nitrogen and Coliform Bacteria

Prompton Reservoir drinking water was in compliance with PADEP criteria for inorganic nitrogen contaminants, nitrate and nitrite, and coliform bacteria contaminants (Table 3-16). Following laboratory testing, drinking water monitoring results were recorded on Safe Drinking Water Act (SDWA-S and SDWA-4) forms and submitted to the appropriate state environmental agencies.

Table 3-16. Concentrations of nitrate and nitrite, and results of coliform bacteria monitoring of drinking water sampled from the public water fountain located in the overlook building at Prompton Reservoir during 2002

Parameter	Sampling Dates		PADEP Regulatory Level	Detection Limits	Method
	19 June	20 August			
Nitrate as N (mg/L)	ND	ND	10.0	0.5	SM4500
Nitrite as N (mg/L)	ND	ND	1.0	0.5	SM4500
E. coli (CFU)	Absence	Absence	Presence	10	SM 9223
Total Coliform (CFU)	Absence	Absence	Presence	10	SM 9223

3.6.3 Historical Drinking Water Quality

Drinking water quality has been monitored at Prompton Reservoir over the past 21 years. Versar (1996) compiled the results from all of the previous years into a single database to facilitate water quality comparisons. Historical data from drinking water quality parameters were compared to their respective PADEP standards. Of 26 parameters summarized, three had incidences of noncompliance with drinking water standards from 1983 to present (Table 3-17). Iron, lead, and corrosivity were most often not in compliance with PADEP criteria; there were no parameters not in compliance during 2002 monitoring.

Table 3-17. Drinking water parameters exceeding PADEP criteria at Prompton Reservoir from 1986 to 2002

Parameter	Monitoring Date	Result	Criteria
Iron (mg/L)	16 July 1991	0.70	0.30
	2 June 1993	0.42	0.30
	9 September 1993	0.47	0.30
	25 May 1994	0.36	0.30
	17 June 1997	0.37	0.30
	9 June 1998	0.42	0.30
Lead (mg/L)	15 June 1987	0.024	0.015
	15 July 1991	0.020	0.015
	26 July 1994	0.034	0.015
Corrosivity	8 June 1998	-0.93	Non-negative
	22 June 1999	NEG	Non-negative

4.0 SUMMARY

The USACE implements a yearly monitoring program at Prompton Reservoir to evaluate potential public health concerns. In general, the monitoring programs emphasize measuring water quality and sediment contamination. Monitoring results are compared to state and federal standards to evaluate the condition of Prompton Reservoir. The 2002 monitoring program of Prompton Reservoir comprised four major elements:

- Water quality monitoring of physical/chemical parameters at fixed stations from May through October;
- monthly water quality monitoring of nutrient parameter concentrations, coliform bacteria contaminants from May through October;
- sediment priority pollutant monitoring for PCB's, pesticides, and volatile organic compounds at a fixed station in the deepest part of the reservoir; and
- drinking water monitoring conducted at the outside spigot of the maintenance building.

4.1 WATER QUALITY MONITORING

The water quality of Prompton Reservoir was not in compliance with the PADEP standard for dissolved oxygen (DO) throughout the monitoring period. The water quality standard for DO is a minimum concentration of 5 mg/L. Additionally, measures of pH during August at the surface stations in the reservoir (PR-2 and PR-3) were not in compliance with the PADEP criteria for pH. The water quality standard for pH is an acceptable range from 6 to 9.

Nutrient levels in Prompton Reservoir were acceptable during 2002. Nutrient parameters nitrite and nitrate were in compliance with their respective PADEP water quality standards for all waters of the reservoir. Total dissolved solids concentrations in the water column were also in compliance with PADEP standards of less than 500 mg/L throughout the monitoring period. Only two measures of ammonia may have exceeded corresponding criteria. The ammonia concentrations at the surface of stations PR-2 and PR-3 in August were 0.08-mg/L and less than the method detection limit of 0.05-mg/L, respectively. However, the ammonia criteria at the corresponding temperature and pH values are 0.040 and 0.042-mg/L.

The trophic status of Prompton Reservoir was defined, independently, by Carlson's trophic state index and EPA criteria. Both classifications were based on concentrations of chlorophyll *a* and secchi disk depths. Carlson's trophic state index classifies the reservoir as mesoeutrophic/eutrophic. However, EPA classifies Prompton Reservoir as mesotrophic/ eutrophic.

Prompton reservoir was in compliance with the PADEP water quality standards for bacteria contamination during 2002. The geometric mean among all fecal coliform counts in each month was less than the PADEP water quality standard, a maximum of 200 colonies/100-ml.

4.2 MONITORING PROGRAM TRENDS

Regression analysis of long-term trends suggested that significant water quality changes have occurred in Prompton Reservoir over the past 28 years. Regression analysis for total nitrogen, total dissolved solids, and fecal coliform data indicated that average concentrations have significantly decreased since the late 1970s. Significant reductions of total nitrogen have occurred in the reservoir at station PR-2 and downstream at PR-4 for both spring and summer seasons. Total dissolved solids showed a significant reduction downstream during the summer season. In addition, a significant decreasing trend was observed for fecal coliform in the reservoir (PR-2) during the summer season.

Trends computed for individual stations using the Mann-Kendall test indicated significant water quality changes in the reservoir (PR-2 and PR-3) and upstream (PR-1) in the Prompton Reservoir watershed. Ammonia and total inorganic nitrogen appear to be decreasing at these stations in both seasons. TDS was decreasing only at these stations in summer as well as during the spring for PR-3. Fecal Coliform showed a decreasing trend in the summer at PR-2.

4.3 SEDIMENT PRIORITY POLLUTANT MONITORING

Prompton Reservoir was in compliance with NJDEP soil guidelines in 2002. Concentrations of all PCB, pesticides, volatile organic compounds were less than the screening guidelines.

4.4 DRINKING WATER MONITORING

Drinking water from the outside spigot of the maintenance building of Prompton Reservoir was in compliance with PADEP criteria for drinking water standards for primary and secondary during 2002 monitoring period.

5.0 RECOMMENDATIONS

The USACE intends to continue monitoring Prompton Reservoir in future years to evaluate trends and to identify potential environmental problems related to human development within the watershed. The USACE is continually seeking to improve the quality and cost-effectiveness of the information gathered as part of this effort. Below, we present recommendations for improving the monitoring program:

Recommendation 1: Add a monitoring component to assess relative loadings of nutrients, toxic chemicals, and sediment from each of the major watersheds draining into the Prompton Reservoir.

The Prompton Reservoir contains several feeder streams which drain different watersheds. Each of these watersheds has different land use characteristics (e.g., residential, agricultural, forested ecosystems) each of which may contribute a different suite of chemical loadings to the reservoir. Management of water quality problems in the reservoir will require an understanding of the relative loadings of nutrients, toxics, and sediment from each watershed, and in which watersheds these loadings are changing most rapidly. Developing this information could be accomplished by deploying automatic samplers into the major feeder streams to obtain composite samples over randomly selected 24-hour periods, stratified by season, and by conducting special sampling during storm events.

Recommendation 2: Adjust nutrient concentration to account for yearly differences in flow.

The trends presented in this report have not taken into account the effects of flow volume on parameter concentrations. Further analyses using concentrations weighted for stream flow (from USGS gauging stations) would provide a better estimate of trends within the system. These data could be used to calculate total nutrient loadings (kg/day) and could form the basis for creating a nutrient budget for the system. The observed trends should be correlated to management practices in the watershed (e.g., sewage treatment plant construction or upgrades, changes in agricultural activities) to help explain water quality improvements or degradations observed during the monitoring period.

Recommendation 3: Conduct a watershed modeling effort.

A survey of all nutrient and pollutant sources (point source and non-point source) within the Prompton Reservoir watershed could be conducted and presented in a GIS format. Using predicted loadings from the various pollutant sources identified within the watershed, a simple nutrient/DO prediction model could be constructed and verified with the long-term data set. This model could be used to predict the degree of improvement in reservoir water quality that could be obtained through various nutrient control measures such as sewage treatment upgrades and reduced fertilizer application to farmlands.

6.0 REFERENCES

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APPENDIX A

STRATIFICATION MONITORING

Table A-1. Summary of stratification monitoring at Prompton Reservoir in 2002

Station	Date	Depth (F)	Temp ©	pH	DO (mg/L)	DO (%)	Cond (ms/cm)
PR1	21-May	**0**	6.74	7.5	10.64	87.1	0.0622
PR1	19-Jun	**0**	14.54	7.62	9.26	90.9	0.0713
PR1	23-Jul	**0**	21.38	7.91	7.54	85.3	0.0986
PR1	20-Aug	**0**	20.72	7.59	7.1	79.2	0.0922
PR1	02-Oct	**0**	14.85	7.73	8.89	87.9	0.0965
PR2	21-May	25	9.62	7.14	10.43	91.9	0.085
PR2	21-May	20	9.67	7.12	10.74	94.6	0.086
PR2	21-May	15	9.68	7.12	10.75	94.6	0.087
PR2	21-May	10	9.7	7.11	10.76	94.8	0.088
PR2	21-May	5	9.71	7.11	10.79	95	0.089
PR2	21-May	0	9.7	7.09	10.81	95.1	0.087
PR2	19-Jun	20	14.76	7.35	5.25	51.8	0.0665
PR2	19-Jun	15	15.16	7.14	6.1	60.7	0.0667
PR2	19-Jun	10	15.78	7.13	6.46	65.1	0.0662
PR2	19-Jun	5	18.97	7.22	8.39	90.4	0.0673
PR2	19-Jun	0	19.25	7.33	8.52	92.3	0.0675
PR2	23-Jul	15	21.8	7.19	0	0	0.0972
PR2	23-Jul	10	23.32	7.2	0.54	6.3	0.0871
PR2	23-Jul	5	25.98	7.57	4.58	56.5	0.083
PR2	23-Jul	0	27.03	8.91	6.78	85.2	0.0834
PR2	20-Aug	15	21.71	7.25	0.6	6.9	0.1054
PR2	20-Aug	10	22.6	7.23	0.28	3.2	0.0912
PR2	20-Aug	5	26.41	9.45	8.29	103	0.0929
PR2	20-Aug	0	26.51	9.67	9.41	117.1	0.093
PR2	02-Oct	15	16.19	7.5	5.72	58.2	0.0903
PR2	02-Oct	10	16.97	7.51	6.57	67.9	0.0879
PR2	02-Oct	5	17.82	7.75	7.6	80	0.0864
PR2	02-Oct	0	18.9	8.8	9.81	105.6	0.0872
PR3	21-May	23	10.71	7.09	10.78	97.1	0.084
PR3	21-May	20	10.76	7.06	10.27	92.7	0.084
PR3	21-May	15	11.03	7.05	10.21	92.7	0.085
PR3	21-May	10	11.1	7.04	10.22	92.9	0.084
PR3	21-May	5	11.2	7.04	10.26	93.6	0.084
PR3	21-May	0	11.21	7.04	10.31	93.9	0.085
PR3	19-Jun	30	11.45	6.8	0	0	0.0727
PR3	19-Jun	25	12.71	6.68	0.97	9.2	0.0695
PR3	19-Jun	20	14.79	6.73	3.84	37.9	0.0675
PR3	19-Jun	15	15.42	6.75	4.35	43.6	0.0681
PR3	19-Jun	10	16.13	6.74	4.71	47.9	0.0687
PR3	19-Jun	5	17.88	7.05	8.21	86.6	0.0664
PR3	19-Jun	0	19.31	7.27	8.34	90.5	0.068

Table A-1. (Continued)							
Station	**Date**	**Depth (F)**	**Temp ©**	**pH**	**DO (mg/L)**	**DO (%)**	**Cond (ms/cm)**
PR3 (Con't)	23-Jul	30	11.3	7.12	0	0	0.172
		25	13	7.01	0	0	0.1088
		20	18.22	7.06	0	0	0.1007
		15	21.36	7.12	0	0	0.0866
		10	23.8	7.09	1.88	22.3	0.0806
		5	26.11	8.58	5.88	72.7	0.0826
		0	26.2	9.06	6.96	86.1	0.0832
	20-Aug	30	12.14	6.77	0	0	0.235
		25	14.27	6.92	0	0	0.1376
		20	20.13	7.04	0	0	0.1102
		15	21.9	7.11	0	0	0.0865
		10	23.25	7.1	0.65	7.6	0.0836
		5	27.05	9.43	7.94	99.7	0.0953
		0	27.02	9.62	9.43	118.5	0.0955
	02-Oct	30	15.15	7.47	3.31	33	0.0959
		25	15.26	7.45	4.15	41.4	0.0919
		20	15.69	7.45	4.96	50	0.0899
		15	16.31	7.43	5.4	55.1	0.0888
		10	17.16	7.44	5.58	57.9	0.0866
		5	17.93	7.63	7.01	74	0.0864
		0	18.02	8.02	8.34	88.1	0.0857
PR4	21-May	0	11.14	7.11	11.33	102.8	0.086
	19-Jun	0	18.53	7.25	8.3	88.6	0.0679
	23-Jul	0	21.4	7.65	6.05	68.4	0.0878
	20-Aug	0	21.05	7.6	5.72	64.3	0.0886
	02-Oct	0	16.37	7.72	7.49	76.5	0.0891

APPENDIX B

WATER COLUMN CHEMISTRY MONITORING LABORATORY ANALYSIS CERTIFICATES

APPENDIX C

SEDIMENT PRIORITY POLLUTANT LABORATORY ANALYSIS CERTIFICATES

APPENDIX D

DRINKING WATER MONITORING
LABORATORY ANALYSIS CERTIFICATES

APPENDIX E

SCOPE OF WORK